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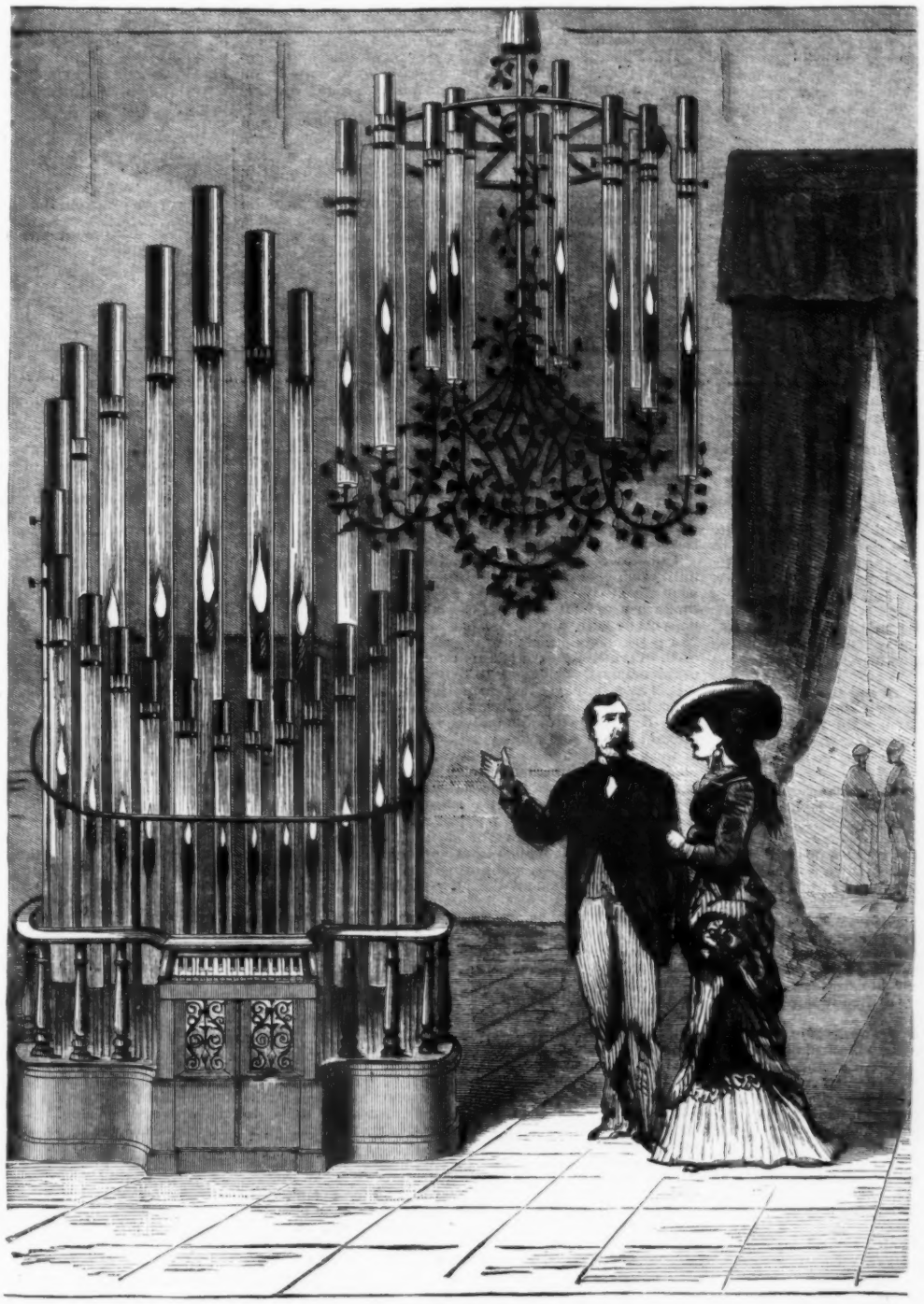
THE PYROPHONE.

It is well known that if a hydrogen flame is placed in a glass tube a sound is produced which varies according to the diameter of the tube and the size of the flame. Higgins called attention to this in 1777, and was followed by examinations and experiments made in this line by Count Schaffgotsch, Tyndall, De Luc, Hermstadt, and Count Puschkin. In 1818, Faraday explained the formation of the tones as being produced by a series of very rapid explosions within the glass tube. The physicist, Scherer, proved that the combustion of the gas produced a vacuum into which the air passed with great rapidity and thus produced a sound. Based upon the above described phenomenon, Frederic Kastner built a musical instrument which he has named the pyrophone. It consists of a series of glass tubes of different diameters and lengths, each containing a gas burner of peculiar construction. Gradually, as the flames of the burners are decreased, a sound of greater strength is produced. Mr. Kastner does not use the hydrogen flame, but uses two gas flames, which he brings closer together or separates according to the desired strength of the sound to be produced. The burners are connected, by means of electric wires, with a keyboard, which is manipulated in the usual manner, and accordingly as the keys are depressed the sounds will be produced. The pyrophone is shown in the annexed cut, on the left side. The singing chandelier, shown in the top of the cut, is another invention of Mr. Kastner's, and is constructed in the same manner as the pyrophone. It consists of ornamental metal work supporting the glass tubes, the burners in the said tubes being connected with a keyboard in the same manner as in the pyrophone. The burner for regulating the size of the flame is very ingenious. In the cut representing the same, *a* is a gas burner, of which as many as nine are arranged in a circle. So as to show the burner more distinctly in our drawing, we have shown only two. The burners are connected with the main gas pipe, *e*, by flexible tubes, *b*, and below the burner an electro-magnet, *d*, is provided, which is connected with the burners and separates them a greater or less distance, and thus produces the desired sounds. The pyrophone equals the organ in depth, power, and quantity of tone, and surpasses it in the beauty and loveliness of the sounds.



THE PYROPHONE, OR FLAME ORGAN.

FREDERIC KASTNER.

Frederic Kastner, who is known to the scientific world as the inventor of the pyrophone, has recently died, at the early age of thirty years. He was the son of an Alsatian composer of some merit, Georges Kastner, and was himself an accomplished musician. Educated partly at Paris and partly at Strassburg, he imbibed a love of science, and at the early age of fourteen years was already assisting his teachers in the chemical laboratory. When seventeen years of age he invented and patented a novel form of electromotor, in which a series of electro-magnets were caused to act in succession upon a rotating arbor. After the war of 1870–71, in which he was driven from Strassburg, he devoted himself to studying the properties of musical flames. The discovery of Higgins, in 1777, that a hydrogen flame burning within the lower end of an open glass tube could set up a musical note, had been the starting point of a number of hitherto barren attempts by Schaffgotsch and others. Without knowing anything of the experiments of Schaffgotsch, Barrett, or Tyndall, young Kastner set to work to experiment, with the determination to construct a musical instrument on this principle. For two years he worked at the subject, endeavoring to temper the harsh tones of the flames and to produce a purity and constancy in their notes. He tried tubes of different sizes and forms. He varied the form of the gas jet, and essayed to introduce two or more jets into one tube. At last, in 1871, he discovered that when he employed *two* flames he could control their note at will, being silent when both were close together, but producing sound when they were separated. This phenomenon, which Kastner called the interference of flames, was the real starting point of Kastner's pyrophone or flame organ, which he patented in 1873. This organ had for its pipes glass tubes of different lengths, two hydrogen flames burning in each at the proper height. A very simple lever arrangement served to separate the flames at will. In this form the instrument was presented to the Académie des Sciences at Paris, and publicly exhibited. Two subsequent improvements followed. A circle of small jets of common coal gas was found to answer quite as well as the two hydrogen jets, the circle being constructed so that by a simple mechanical contrivance it could be increased or diminished in size, thus separating or reuniting the flames at will. The second improvement was the application of electric currents and an electromagnetic apparatus, enabling the flame organ to be played at a distance. The first instrument of this kind constructed by Kastner was in the form of a singing-luster hung from the chandelier in his mother's house. The pyrophone was shown at the Royal Institution in January, 1875, and at the Society of Arts in the succeeding month. It was also shown at the Loan Collection of Scientific Apparatus at South Kensington in 1876, and at the Paris Exhibition in 1878. In 1876, moreover, an account of the instrument and of the researches which led to its construction was published by Kastner under the title of "Flammes Chantantes." The strange, weird tones produced by the instrument attracted the notice of musicians. Gounod sought to introduce the pyrophone into his opera of "Jeanne d'Arc," and Koenemann at Baden Baden, in 1879, actually introduced the instrument on one occasion. A decline, however, seized the young inventor, whose strength for some years ebbed slowly away, and he died all too soon to see his invention fairly recognized by the public.—*Nature.*

PROF. PLANTAMOUR.

The daily journals record the decease on the 7th of September, at Geneva, of Prof. Plantamour, for many years Director of the Observatory and Professor of Astronomy in the university of that city.

Emile Plantamour was born at Geneva in 1815, and received his early education in the old college founded by Calvin. He entered the Geneva Academy in 1833, where he became a pupil of Alfred Gautier, then in the Chair of Astronomy, and on graduating, adopted this science as his profession. He studied two years at Paris under Arago, and subsequently proceeded to Königsberg, where he became a pupil of the illustrious Bessel. His inaugural dissertation was upon the methods of calculating the orbits of comets, and he obtained the degree of Doctor in 1839. He subsequently visited Berlin, where Encke was then one of the great masters of astronomical science of the day. On returning to Geneva he was appointed Professor of Astronomy and Director of the Observatory; these positions he continued to occupy nearly up to the time of his decease. The observations made under his direction were published in various parts, commencing in 1843, and related to astronomy, magnetism, and meteorology. He took part in a number of geodetical operations in Switzerland, and was the representative of Geneva on the Swiss Geodesic Commission.

Plantamour was a man of considerable private means, and hence was independent of the very modest salary attaching to his official position. A few years since he presented a 10 inch refractor to the Observatory of Geneva, and a building suitable for it was erected at his expense. This instrument has already done good work in the hands of Dr. Meyer. Plantamour devoted much attention to cometary astronomy, one of his most elaborate investigations being his determination of definitive elements of Mauvais's comet of 1844, which was observed from July 7 in that year to the middle of March, 1845, and therefore offered a favorable

opportunity for the calculation of the true form of orbit. Plantamour's result was a somewhat notable one; after taking into account the effect of the attraction of the planets during the comet's visibility, he concluded that at the passage through perihelion in October, 1844, the comet was moving in an elliptical orbit with a period of revolution of 102,050 ± 3,090 years. In 1846 he made extensive calculations bearing upon the motion of the two heads of Biela's comet, the results of which will be found in No. 584 of the *Astronomische Nachrichten*. He further discussed the elements of what was called at the time "Galle's second comet," 1840 II. (*Astron. Nach.*, No. 475-6). In this paper he pointed out some anomalies in the intensity of the comet's light, similar to what has been observed from time to time in other comets.

Plantamour was placed on the list of Associates of the Royal Astronomical Society in 1844; he was a corresponding member of the Academy of Sciences of the Institute of France, and honorary member of the Academy of Turin. Few of those colleagues who were at work at the commencement of his astronomical life now remain.—*Nature*.

DEARBORN OBSERVATORY.

DEARBORN OBSERVATORY, pertaining to the Chicago University, possesses one of the largest and finest refracting telescopes in the world. The object glass is 18½ inches in the clear, focal length 23 feet, Alvan Clark maker. Prof. G. W. Hough, the director, in his recent report says that, during the past year, the work with the great equatorial has been mostly confined to the study of special objects and phenomena, for which great optical power, combined with good definition, is desirable.

The following subjects were specially studied:

(1) The Great Comet of 1881.
(2) The planet Jupiter.
(3) The Satellites of Uranus.
(4) Difficult double stars.

THE PLANET JUPITER.

The report says that the various spots and markings on the planet Jupiter, as heretofore, have been carefully studied by means of micrometer measurements, accompanied by eye sketches when necessary. The work on this planet during the past three oppositions enables us to decide definitely on some points regarding the phenomena exhibited on his disk; but the actual condition of his surface cannot yet be regarded as fully ascertained. The experience, however, of the past three years has shown conclusively that direct micrometer measurement is infinitely superior to any method of estimation. In attempting to reconcile the various phenomena alleged to have been seen on his disk, the greatest difficulty exists in determining what is real and what is imaginary. Contemporaneous sketches by different persons, or even by the same observer, show such marked discrepancies that they are of but little use in ascertaining suspected changes.

Our observations during the past three years confirm the statement heretofore made, that the changes taking place on the disk are slow and gradual; in fact, directly contrary to the doctrine taught in text-books and the history of astronomy.

It seems probable, that when the subject is more carefully studied, the phenomena seen on the disk of Jupiter will be found to be periodical, in a manner analogous to that exhibited on the surface of the sun. It seems probable also, that some of the markings are comparatively permanent in locality.

The hypothesis presented in last year's report, that the surface of the planet is liquid, or in a plastic condition, seems to accommodate known phenomena better than any other yet proposed.

The observations made during 1879 and 1880 showed that the great red spot was retrograding with an accelerated velocity. This drifting has continued up to the present time, and with such remarkable uniformity that the position of the spot at any future period can be very accurately computed.

The apparent rotation period has increased about four seconds since the opposition of 1879, indicating a total drift of the red spot in longitude of 40,000 miles; being about 10,000 for the first year, and 30,000 for the second year. These observations prove that the red spot is not the solid portion of the planet, as has been held by a number of astronomers. One of the most curious features of this interesting object is its stability. Here we have an immense floating island, 29,600 miles in length by 8,300 miles in breadth, which has maintained its shape and size, without material change, during more than three years.

Between the oppositions of 1880 and 1881 the length has dimini-hed 0·25″, or 580 miles; the breadth has increased 0·12″, or 290 miles; and that it has drifted in latitude 0·26″, or 600 miles.

The position of its major axis was essentially the same, and so far as the eye could judge the elliptical outline was the same in 1882 as in 1879. The color, also, has not materially altered. It has been recently stated by some astronomers that the spot was fading. If such be the case, I have failed to recognize the fact. On February 2, 1882, the seeing was good, when the color was found to be the same as formerly, viz., a light pink.

The color, both of the spot and belts, varies at different times, depending on the condition of the seeing. The spot and belts generally appear as a dull brick color, but on rare occasions the pink tint is very marked, especially in the red spot.

Several interesting plates representing various appearances of the planet Jupiter are given in the report.

THE PRESENT PHASE OF THE ANTIQUITY OF MAN.

By PROF. W. BOYD DAWKINS.

AT the recent meeting of the British Association, in the Department of Anthropology, Professor Boyd Dawkins delivered the following address:

I propose to place before you the present phase of the inquiry into the antiquity of man, and to point out what we know of the conditions of life—though our knowledge of them is imperfect and fragmentary—under which man has appeared in the Old and in the New World. The rudely chipped implements left by the primeval hunters in the beds of gravel of Hampshire and Wiltshire, and along the shores of Southampton Water and elsewhere, are eloquent of the presence of man in this district at a time when there was no Southampton Water, and the elephant and the reindeer wandered over the site of this busy mart for ships; when the Isle of Wight was not an island, and the river-drift hunter could walk across from Portsmouth to Cowes, with no obstacle except that offered by the rivers and morasses.

I propose to enter upon the labors of Prestwich, Evans, Stevens and Blackmore, Codrington, Read, Brown, and other investigators in this country, and to combine the results of their inquiries with those in other countries, and with some observations of my own, which I was able to make in 1880, during my visit to the United States.

The most striking feature in the study of the Tertiary period is the gradual and orderly succession of higher types of mammalia, so well-defined and so orderly that I have used it as a basis for the classification of the Tertiary period. We find the placental mammals becoming more and more specialized as we approach the frontier of history. The living orders appear in the Eocene, the living genera in the Miocene, a few living species in the Pliocene, and the rest in the Pleistocene. The characteristics of this evolution of living forms may be summed up as follows:

VI. Historic—in which the events are recorded in history. Events included in history. Founded on discoveries, documents, refuse-heaps, caves, tombs.

V. Prehistoric—in which domestic animals and cultivated fruits appear. Man abundant; domestic animals, cultivated fruits, spinning, weaving, pottery making, mining, commerce; the neolithic, bronze, and iron stages of culture. Camps, habitations, tombs, refuse-heaps, surface accumulation, caves, alluvia, peat bogs, submarine forests, raised beaches.

IV. Pleistocene—in which living species of placental mammals are more abundant than the extinct. Man appears: *anthropidæ;* the palæolithic hunter; living species abundant. Refuse-heaps, contents of caves, river deposits, submarine forests, bowlder clay, moraines, marine sands, and shingle.

III. Pliocene—in which living species of placental mammals appear. Living species appear; apes, *simiadæ*, in southern Europe. Fresh water and marine strata; volcanic *débris* (Auvergne).

II. Miocene—in which the alliance between living and placental mammals is more close than before. Living genera appear; apes, *simiadæ*, in Europe and North America. Fresh water and marine strata; volcanic *débris* (Auvergne); lignites.

I. Eocene—in which the placental mammals now on earth were represented by allied forms belonging to existing orders and families. Living orders and families appear; lemurs (*lemuridæ*) in Europe and North America. Fresh water and marine strata; lignites.

The orders, families, genera, and species in the above summary, when traced forward in time, fall into the shape of a genealogical tree, with its trunk hidden in the secondary period, and its branchlets (the living species) passing upward from the Pliocene, a tree of life, with living mammalia for its fruit and foliage. Were the extinct species taken into account, it would be seen that they fill up the intervals separating one living form from another, and that they too grow more and more like the living forms as they approach nearer to the present day.

It must be remembered that in the above definitions the fossil marsupials are purposely ignored, because they began their specialization in the secondary period, and had arrived in the Eocene at the stage which is marked by the presence of a living genus—the opossum (*Didelphys*). It will be seen that our inquiry into the antiquity of man is limited to the last four of the divisions.

The most specialized of all animals cannot be looked for until the higher mammalia by which he is now surrounded were alive. We cannot imagine him in the Eocene age, at a time when animal life was not sufficiently differentiated to present us with any living genera of placental mammals. Nor is there any probability of his having appeared on the earth in the Miocene, because of the absence of higher placental mammals belonging to living species.

It is most unlikely that man should have belonged to a fauna in which no other living species of mammal was present. He belongs to a more advanced stage of evolution than the mid-Miocene of Thenay. Up to this time the evolution of the animal kingdom had advanced no further than the Simiadæ in the direction of man, and the apes then haunting the forests of Italy, France, and Germany represent the highest type of those on the earth. We may also look at the question from another point of view.

If man were upon the earth in the Miocene age, it is incredible that he should not have become something else in the long lapse of ages, and during the changes in the conditions of life by which all the Miocene land mammalia have been so profoundly affected, that they have been either exterminated, or have assumed new forms. It is impossible to believe that man should have been an exception to the law of change, to which all the higher mammalia have been subjected since the Miocene age. Nor in the succeeding Pliocene age can we expect to find man upon the earth, because of the very few living species of placental mammals then alive. The evidence brought forward by Professor Capellini, in favor of Pliocene man in Italy, seems both to me and to Dr. Evans unsatisfactory, and that advanced by Professor Whitney in support of the existence of Pliocene man in North America cannot, in my opinion, be maintained.

It is not until we arrive at the succeeding stage, or the Pleistocene, when living species of mammalia begin to abound, that we meet with indisputable traces of the presence of man on the earth.

As a preliminary to our inquiry we must first of all define what is meant by the Pleistocene Period. It is the equivalent of the Quaternary of the French, and the Postpliocene of the older works of Lyell, and it includes all the phenomena known in latitudes outside the Arctic Circle, where ice no longer is to be found, under the name of glacial and inter-glacial. It is characterized in Europe, as I have pointed out in my work on "Early Man in Britain," by the arrival of living species, which may be conveniently divided into five groups, according to their present habitats.

The first consists of those now found in the temperate zones of Europe, Asia, and North America. It includes the following animals: mole, musk shrew, common shrew, mouse, beaver, hare, pika, pouched marmot, water vole, red field vole, short-tailed field vole, continental field vole, lynx, wild cat, wolf, fox, marten, ermine, stoat, otter, brown bear, grisly bear, badger, horse, bison, urus, saiga antelope, stag, roe, fallow deer, wild boar.

The second consists of animals of arctic habit: Russian vole, Norwegian lemming, Arctic lemming, varying hare, musk sheep, reindeer, Arctic fox, glutton.

The third is composed of those which enjoy the cold climate of mountains: The snowy vole, Alpine marmot, chamois, and ibex. These animals invaded Europe from Asia, and as the cold increased the temperate group found their way into Southern Europe, and Northern Africa, while the Arctic division pushed as far south as the Alps and Pyrenees.

The fourth group of invading forms is represented by animals now only found in warm countries: Porcupine, lion, panther, African lynx, Caffre cat, spotted hyena, striped hyena, and African elephant. This group of animals is found as far to the north as Yorkshire and as far to the west as Ireland. Among the southern animals, too, must be reckoned the hippopotamus, which lived as far north as Britain in the Pliocene age, and in the Pliocene occurs in caves and river deposits in intimate association with some arctic species, such as the reindeer.

The fifth group is composed of extinct species, hitherto unknown in Europe in the Pleistocene age, such as the straight tusked elephant, mammoth, the pygmy elephants, woolly and small-nosed rhinoceroses, the Irish elk, pygmy hippopotamus, and the cave bear. The question as to which of these groups the River-drift man belongs, must be deferred till we can take a survey of the evidence elsewhere.

The early Pleistocene division is characterized by the presence of the temperate and southern species in Britain; the middle stage by the presence of the arctic, but not in full force; and the late Pleistocene by the abundance of Arctic animals, not only in Britain, but on the Continent as far as the Alps and Pyrences, and the lower valley of the Danube.

The first view which we get of the Pleistocene mammalia in this country is offered by the accumulations associated with the buried forest of East Anglia. It extends for more than 40 miles along the shores of Norfolk and Suffolk, from Cromer to Kessingland, passing into the cliff on the one hand and beneath the sea on the other. The forest was mainly composed of somber Scotch firs and dark clustering yews, relieved in the summer by the lighter tinted foliage of the spruce and the oak, and in the winter by the silvery gleam of the birches, that clustered thickly with the alders in the marshes and stood out from a dense undergrowth of sloes and hazels. Among the animals living in this forest of the North Sea were species which haunted the valleys of the Upper Seine at the time, such as the southern elephant, the Etruscan rhinoceros, the deer of Carnutes, extinct horses, and the large extinct beaver. There were in addition the shaggy-maned mammoth, the straight-tusked elephant, and the big-nosed rhinoceros. The stag, the roe, the Irish elk, were in the glades, Sedgwick's deer, with its many-pointed antlers, the verticorn deer, and the gigantic urus. The undergrowth formed a covert for the wild boar and for beasts of prey, many in species and formidable in numbers. The cave bear, the bugest of its kind, the saber-toothed lion, the wolf, the fox, and the wolverine. Among the smaller animals were to be noted the musk shrew, the common shrew, and a vole. In the trees were squirrels. Under foot the moles raised their hillocks of earth, and from between the lofty fronds of the Osmund royal beavers were to be seen building their lodges, and the hippopotamus as he emerged from the water and disappeared in the forest. Out of the thirty species identified, no less than seventeen are living in some part of the world, and we have there obviously the stag in the evolution of mammalian life when the living species were becoming more abundant than the extinct. We may note, too, the absence of arctic animals in this fauna, more particularly of the reindeer. The presence of these animals in Norfolk and Suffolk implies that at this time Britain was united to the Continent, and the presence of fossil species found in France indicates a southern extension of land in the direction of the Straits of Dover. The forest covered a large portion of the area of the North Sea, and in all probability the Atlantic seaboard was then at the 100-fathom line of the west coast of Ireland. No traces of man have as yet been discovered in these deposits, although the large percentage of living species of higher mammalia indicates that the geological clock had struck the hour when he may be looked for. The living species in the forest bed are to be looked upon as an advanced guard of a great migration of Asiatic and African species, finding their way into Northwestern Europe, over the plains of Russia and over barriers of land connecting Northern Africa with Spain by way of Gibraltar, and with Italy by way of Malta and Sicily. In the course of time other living species followed, and the extinct species became more rare. In the deposits, for instance, of the ancient Thames, at Ilford and Grays Thurrock, in Essex, and at Erith and Crayford, in Kent, out of twenty-six species, six only belong to extinct forms—the new comers, comprising the lion, wild-cat, spotted hyena, and otter, the bison, and the musk sheep. A flint flake, discovered by the Rev. Osmund Fisher, at Crayford, a second, discovered by Messrs. Cheadle and Woodward, at Erith, prove that man was present in the valley of the Thames at this time; while the more recent discoveries of Mr. Flaxman Spurrell indicate the very spots where the palæolithic hunter made his implements, and proved that he used implements of the River-drift type, so widely distributed over the surface of the earth. The arctic animals at this time were present, but not in full force, in Southern Britain, and the innumerable reindeer which characterize the later deposits of the Pleistocene age had not, so far as we know, taken possession of the valley of the Thames.

To what stage in the Pleistocene period are we to refer these traces of the River-drift hunter? The only answer which I am able to give is that the associated animals are intermediate between the Forest-bed group and that which characterizes the late Pleistocene division in the region extending from the Alps and the Pyrenees as far north as Yorkshire. Nor am I able to form an opinion about their relation to the submergence of Middle or Northern Britain under the waves of the glacial sea. They are quite as likely to be pre as post glacial. The rudely chipped implements of the River-drift hunter lie scattered through the late Pleistocene river deposits in Southern and Eastern England in enormous abundance, and as a rule in association with the remains of animals of arctic and of warm habit as well as some or other of the extinct species of reindeer and hippopotamus along with mammoth and woolly rhinoceros.

What is their relation to the submergence of the land and the lowness of the temperature which combined together have resulted in the local phenomena known as glacial and inter-glacial? The geographical change in Northern Europe at the close of the Forest-bed age was very great. The forest of the North Sea sank beneath the waves and Britain was depressed to a depth of no less than 2,300 feet in the Welsh mountains, and was reduced to an archipelago of islands, composed of what are now the higher lands. The area of the English Channel also was depressed, and the "silver streak" was wider than it is now, as is proved by the raised beach at Brighton, at Bracklesham, and elsewhere, which marks the sea line of the largest island of the Archipelago, the Southern Island, as it may be termed, the northern shores of which extended along a line passing from Bristol to London. The northern shore of the Continent at this time extended eastward from Abbeville, north of Erzgebirge, through Saxony and Poland, into the middle of Russia,

Scandinavia being an island from which the glaciers descended into the sea. This geographical change was accompanied by a corresponding change in climate. Glaciers descended from the higher mountains to the sea level, and icebergs, melting as they passed southward, deposited their burdens of clay, sand, and erratics, which occupy such a wide area in the portions then submerged of Britain and the Continent. This depression was followed by a re-elevation, by which the British Isles, a part of the Continent, and all the large tract of country within the 100 fathom line again became the feeding grounds of the late Pleistocene mammalia. An appeal to the animals associated with the River-drift implements will not help us to fix the exact relation of man to these changes, because they were in Britain before, as well as after, the submergence, and were living throughout in those parts of Europe which were not submerged. It can only be done in areas where the submergence is clearly defined. At Salisbury, for instance, the River drift hunter may have lived either before, during, or after the southern counties became an island. When, however, he hunted the woolly and leptorhine rhinoceros, the mammoth, and the horse in the neighborhood of Brighton, he looked down upon a broad expanse of sea, in the spring flecked with small icebergs such as those which dropped their burdens in Brackles ham Bay. At Abbeville, too, he hunted the mammoth, reindeer, and horse down to the mouth of the Somme on the shore of the glacial sea. The evidence is equally clear that the River-drift hunter followed the chase in Britain after it had emerged from beneath the waters of the glacial sea, from the fact that the river deposits in which his implements occur either rest upon the glacial clays, or are composed of fragments derived from them, as in the oft-quoted cases of Hoxne and Bedford. Further it is very probable that he may have wandered close up to the edges of the glaciers then covering the higher hills of Wales and the Pennine chain. The severity of the climate in winter at this time in Britain is proved, not merely by the presence of the arctic animals, but by the numerous ice-borne blocks in the river gravels dropped in the spring after the break up of the frosts.

The River-drift man is proved, by the implements which he left behind, to have wandered over the whole of France, and to have hunted the same animals in the valley of the Loire and the Garonne, as in the valley of the Thames. In the Iberian peninsula he was a contemporary of the African elephant, the mammoth, and the straight tusked elephant, and he occupied the neighborhood both of Madrid and Lisbon. He also ranged over Italy, leaving traces of his presence in the Abruzzo, and in Greece he was a contemporary of the extinct pygmy hippopotamus (*H. Pentlandi*). South of the Mediterranean his implements have been met with in Oran, and near Kolea, in Algeria and in Egypt, in several localities. At Luxor they have been discovered by General Pitt-Rivers in the breccia, out of which are hewn the tombs of the kings. In Palestine they have been obtained by the Abbé Richard between Mount Tabor and the sea of Tiberias, and by Mr. Stopes between Jerusalam and Bethlehem. Throughout this wide area the implements, for the most part of flint or of quartzite, are of the same rude types, and there is no difference to be noted between the *haches* found in the caves of Creswell in Derbyshire and those of Thebes, or between those of the valley of the Somme and those of Palestine.

Nor is our survey yet ended. The researches of Foote, King, Medlicott, Hacket, and Ball, establish the fact that the River-drift hunter ranged over the Indian peninsula from Madras as far north as the valley of the Nerbudda. Here we find him forming a part of a fauna in which there are species now living in India, such as the Indian rhinoceros and the arnee, and extinct types of oxen and elephants. There were two extinct hippopotami in the rivers, and living gavials, turtles, and tortoises. It is plain, therefore, that at this time the fauna of India stood in the same relation to the present fauna as the European fauna of the late Pleistocene does to that now living in Europe. In both there was a familiar association of extinct and living forms, from both the genus *Hippopotamus* has disappeared in the lapse of time, and in both man forms the central figure. We are led from the region of tropical India to the banks of the Delaware, in New Jersey, by the recent discoveries of Dr. C. C. Abbott, in the neighborhood of Trenton. After a study of his collections in the Peabody Museum in Cambridge, Massachusetts, I have had the opportunity of examining all the specimens found up to that time, and of visiting the locality in company with Dr. Abbott and Professors Haynes and Lewis. The implements are of the same type as those of the river gravels of Europe, and occur under exactly the same conditions as those of France and Britain. They are found in a plateau of river gravel forming a terrace overlooking the river, and composed of materials washed down from the old terminal moraine which strikes across the State of New Jersey to the westward. The large blocks of stone and the general character of the gravel point out that during the time of its accumulation there were ice-rafts floating down the Delaware in the spring, as in the Thames, the Seine, and the Somme. According to Professor Lewis it was formed during the time when the glacier of the Delaware was retreating ("late glacial"), or at a later period ("post glacial"). The physical evidence is clear that it belongs to the same age as deposits with similar remains in Britain. The animal remains also point to the same conclusion. A tusk of mastodon is in Dr. Cooke's collection at Brunswick, New Jersey, obtained from the gravel, and Dr. Abbott records the tooth of a reindeer and the bones of a bison from Trenton. Here, too, living and extinct species are found side by side.

Thus in our survey of the group of animals surrounding man when he first appeared in Europe, India, and North America, we see that in all three regions, so widely removed from each other, the animal life was in the same stage of evolution, and "the old order" was yielding "place unto the new." The River-drift man is proved by his surroundings to belong to the Pleistocene age in all three.

The evidence of Palæolithic man in South Africa seems to me unsatisfactory, because as yet the age of the deposits in which the implements are found has not been decided.

It remains now for us to sum up the results of this inquiry, in which we have been led very far afield. The identity of the implements of the River-drift hunter proves that he was in the same rude state of civilization, if it can be called civilization, in the old and new worlds, when the hands of the geological clock pointed to the same hour. It is not a little strange that his mode of life should have been the same in the forests to the north and south of the Mediterranean, in Palestine, in the tropical forests of India, and on the western shores of the Atlantic. The hunter of the reindeer in the valley of the Delaware was to all intents and purposes the same sort of savage as the hunter of the reindeer on the banks of the Wiley or of the Solent. It does not, however, follow that this identity of implements implies that the same race of men were spread over this vast tract. It points rather to a primeval condition of savagery from which mankind has emerged in the long ages which separate it from our own time.

It may further be inferred, from his wide-spread range, that the River-drift man (assuming that mankind sprang from one center) must have inhabited the earth for a long time, and that his dispersal took place before the glacial submergence and the lowering of the temperature in Northern Europe, Asia, and America. It is not reasonable to suppose that the Straits of Behring would have offered a free passage, either to the River-drift man from Asia to America, or to American animals from America to Europe or *vice versâ* while there was a vast barrier of ice or of sea, or of both, in the high northern latitudes.

I therefore feel inclined to view the River-drift man as having invaded Europe in pre-glacial time along with the other living species which then appeared. The evidence, as I have already pointed out, is conclusive that he was also glacial and post-glacial.

In all probability the birthplace of man was in a warm if not a tropical region of Asia, in "a garden of Eden," and from this the River-drift man found his way into those regions where his implements occur. In India he was a member of a tropical fauna, and his distribution in Europe and along the shores of the Mediterranean prove him to have belonged either to the temperate or the southern fauna in those regions.

It will naturally be asked, to what race can the River-drift man be referred? The question, in my opinion, cannot be answered in the present stage of the inquiry, because the few fragments of human bones discovered along with the implements are too imperfect to afford any clew. Nor can we measure the interval in terms of years which separates the River-drift man from the present day, either by assuming that the glacial period was due to astronomical causes, and then proceeding to calculate the time necessary for them to produce their result, or by an appeal to the erosion of valleys or the retrocession of waterfalls. The interval must, however, have been very great to allow of the changes in geography and climate, and the distribution of animals which has taken place—the succession of races, and the development of civilization before history began. Standing before the rock-hewn tombs of the kings at Luxor, we may realize the impossibility of fixing the time when the River-drift hunter lived in the site of ancient Thebes, or of measuring the lapse of time between his days and the splendor of the civilization of Egypt. In this inquiry, which is all too long, I fear, for my audience, and all too short, I know, for my subject, I have purposely omitted all reference to the successor of the River-drift man in Europe—the Cave man, who was in a higher stage of the hunter civilization. In the course of my remarks you will have seen that the story told by the rudely chipped implements found at our very door in this place, forms a part of the wider story of the first appearance of man, and of his distribution on the earth—a story which is to my mind not unfitting as an introduction to the work of the Anthropological Section at this meeting of the British Association.

THE OLD AND THE NEW WORLD.

By BISHOP CLARK, of Rhode Island.

THE notion generally prevails that America is more distinctively modern than the other quarters of the earth, and it goes popularly by the name of "the New World." It is also assumed, that whatever culture and civilization exists on this side of the globe, is an importation from some part of Europe. It is true that when Columbus is said to have discovered America—it had been visited by the Northmen long before, but their explorations came to nothing—that portion of the country which most of us inhabit was an uncultivated wilderness; but there were other regions, in both North and South America, where for thousands of years a civilization had flourished which, in some respects, was in advance of that on the other side of the Atlantic.

In the Old World Egypt was "the cradle of civilization," and the points of resemblance between that wonderful land and certain nations that existed on this continent ages ago are most striking. Mexico more truly deserved to be called "the land of pyramids" than Egypt, for they were far more numerous in Mexico than they were in the land of the Nile, and in some cases very much larger. The most gigantic structure of this sort in Egypt is known by the name of Cheops, and it is 746 feet square, covering an area of eleven acres. The pyramid of Cholula in Mexico, as measured by Humboldt, is 1,400 feet square at the base, and covers *forty-five acres*. The construction is substantially the same in both countries, the pyramids being built of hewn stone, originally covered with cement, and penetrated by small galleries, with openings at some distance above the base. They appear to have been applied to the same uses as tombs, temples, and observatories, and face the four points of the compass.

Populous cities were to be seen on this continent, laid out with the highest engineering skill in streets, and court-yards, and parks, and gardens, and the houses adorned with rich and costly furniture, graceful draperies, gold and silver ornaments, and ceramic wares of the nicest finish and most artistic designs. The temples of religion were magnificent beyond description; immense reservoirs were constructed for the public benefit, and supplied with water from the mountains by substantial aqueducts; the walls of massive prisons are still standing in good preservation; the markets were supplied with fresh provisions by means of "fast expresses;" cotton was abundant and cheap, and the calicoes that were woven and printed a thousand years ago still retain the freshness of their colors; the same tools were in use that we are familiar with, and many of the same implements of war, and a great variety of musical instruments; coins were employed as currency; agriculture was reduced to a science, and the process of irrigation carried to the highest perfection. The Inca, or Emperor, identified himself with the work of the husbandman by officiating at grand processions and ceremonials in the temple at the opening of the spring and the close of the harvest.

The facilities for traveling were perhaps the most stupendous feature in that ancient civilization. Carefully constructed roads, from 1,500 to 2,000 miles in length, were opened in Peru, with hotels and post-houses at little intervals, where relays of horses were always kept in readiness for the traveler; these roads were carried over a most precipitous and mountainous country, where deep ravines and low-lying rivers had to be crossed by long suspension bridges, sometimes hundreds of feet from the water. What country was there in Europe at the time of the Middle Ages that could boast of such works as these?

The social condition of some of these old American peoples was, in certain respects, far in advance of that existing in many parts of Europe. In Peru, for instance, there was no abject poverty, and no oppression of the government fell heavily upon the laboring classes. Provision by law was made for the families of those who were slain in war, for widows and orphans deprived of their means of support, for the sick and maimed and decrepit. Abundant supplies of grain were always kept in the public store-houses, as a provision in case of famine. Courts of justice existed for the trial and punishment of offenders, and—unlike what we sometimes see nearer home—the laws were rigidly and impartially administered. The statutes regulating marriage and divorce were much more in accordance with the principles of Christianity than those which prevail here in New England.

The resemblances between the religious ages of the New and the Old World are most extraordinary. The Americans recognized the sun, moon, and planets as the representatives of divinity—they believed in the immortality of the soul and the resurrection of the body—embalming the dead body as the Egyptians did; they had a regular order of priesthood and a magnificent ritual; like the Roman Augurs, the priests predicted the future from an examination of the entrails of animals slain in sacrifice. There were orders of women, vowed to celibacy—vestal virgins or nuns—and the violation of their vows was punished by burning them alive, as was the practice at one time in Europe. The second table of the ten commandments was, in substance, the basis of the moral code and of the civil law. The Peruvian high-priest alone was allowed to enter the Holy of Holies, and, as was the custom among the Jews, he ate the flesh of the sacrifice offered as an atonement, poured the blood upon the ground, and sprinkled it upon stones and walls, and also upon persons. The rainbow was regarded as a sign that the earth would never again be destroyed by a deluge. Water was poured upon the head of children soon after their birth, and then the mouth and breast were touched by the moistened fingers, and a prayer was offered to the effect that the water "may destroy in thee and put away from thee all the things evil and adverse that were given thee before the beginning of the world." Then it was said over the child: "Now does it live anew, and anew it is born; now again it is purified and cleansed."

Among the other extraordinary resemblances in the old civilization of America to that of our European progenitors may be mentioned the fact that they divided the year into twelve months and counted by tens. The trade of the father descended to the son, bards and minstrels sang at the great festivals, toasts were drank, and good health invoked, triumphal arches were erected to commemorate a victory, and the path of the returning conquerors was strewed with leaves and flowers. Fashionable people made their social calls in the same sort of old-fashioned sedan chairs that once abounded in the streets of London.

If I had room I might go on to multiply these points of resemblance almost indefinitely, but enough has been said to provoke the question: "How are we to account for such a condition of society on a continent which our European forefathers had never heard of, and more especially for the extraordinary similarity that existed in the usages and opinions of the western and the eastern nations, which had never been presumed to have been brought in contact with each other?"

One thing is certain, they must have had a common inheritance, and, in the beginning, started from the same source.—*N. Y. Ledger.*

MASTODON SKELETON FOUND.

WHILE making a cut for the extension of the Kentucky Central Railroad on Joseph Mitcher's farm, last Saturday, Thomas M. Farrow, section foreman, and his gang of hands unearthed the skeleton of a gigantic prehistoric animal, supposed to be a mastodon, but its immense size is larger than the remains even of that huge animal of which we ever heard of being found. At any rate the animal belongs to a species long extinct, and entirely unknown to the post-diluvian world. Mr. Farrow, when he discovered the skeleton, had the earth removed from above it carefully as possible, and made the following measurements, which he has kindly furnished us:

Length of animal, 40 feet.
Height, 23 feet 8 inches.
Length of head, 15 feet 4 inches.
Across the knee, 18½ inches.
One bone 10¼ inches in diameter, and another 8 inches in diameter.
Leg from shoulder blade to ankle, 14 feet 7 inches.
End at ankle bone, 7 inches in diameter.
Knee socket, 2 feet 1½ inches around.
Shoulder blade, 3 feet 5 inches wide.
Jaw-bone, 15 inches in diameter.
Bone from ankle to knee, 3 feet 8 inches in length.
One tooth 3 inches wide and 5½ inches long, and three teeth 13 inches long.

The skeleton position was on a ledge of rock, embedded in a mass of tough blue clay, above which was a stratum of yellow clay, covered by about two feet of soil, the whole forming a thickness of some seven feet. The manner in which the teeth is worn indicates the monster to have been of a herbivorous species, and it is not unlikely, from the position in which the bones were found, that the animal got bogged in the bed of tough mud, fell down in its struggles to free itself, and being too unwieldy to arise, perished there. A blast hole charged with a keg and a half of powder had been sunk near the skeleton, which was greatly shattered by the force of the explosion; otherwise Mr. Farrow could have had it taken out more perfectly. Some of the bones are in good state of preservation, but the major portion of them crumbled upon exposure to the air or the slightest touch. About four feet of one of the tusks had been taken out up to last evening, which measured 15 inches in diameter where it joined the head. The fragments of the remains of this huge animal will afford an interesting study for the scientist, and it is Mr. Farrow's intention to donate some of them to the University in Virginia, of which State he is a native.—*Kentuckian.*

A DESOLATE ISLAND.

THE crew of the American steam whaler, Belvidere, have lately visited Wrangell Land; and one of the crew, named Francis Smith, described the island on the return of the whaler to San Francisco. Smith reports that on nearing the shore they perceived the signal planted by Lieutenant Reynolds, of the Corwin, in 1881, which was a small American ensign fastened to a slender piece of driftwood. The island rises abruptly from the sea, though not precipitously. There is no beach to speak of, the land having an average elevation of 10 feet above the surface of the sea. It is surrounded by deep water; and from soundings that the party made an

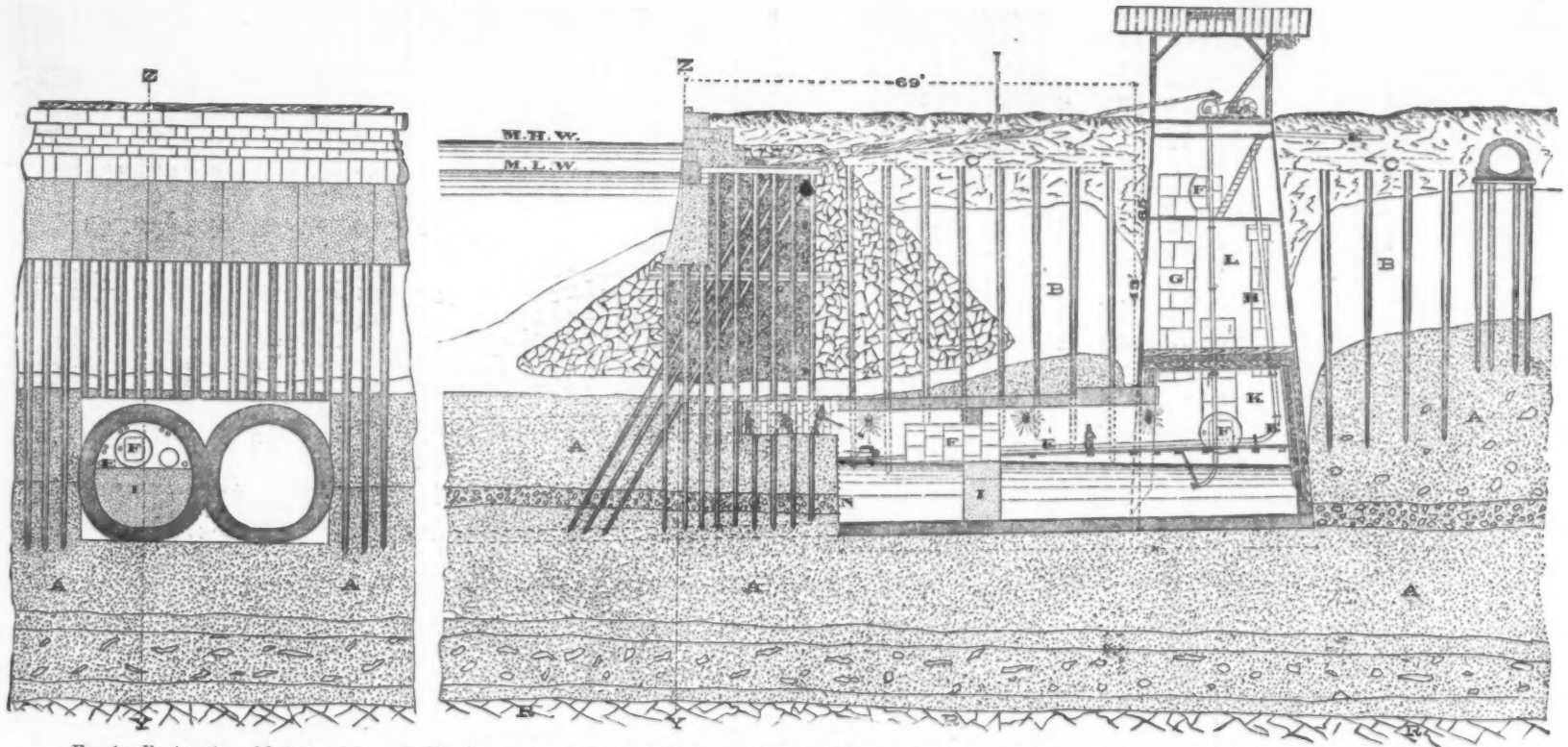


FIG. 1.—Explanation of Letters—AA, sand; BB, dock mud; CC, filling; EE, air pipe; FF, air locks; G, man shaft; H, timber lock; I I, concrete bulkhead for air lock; K, caisson; L, coffer dam; N, iron bulkhead; RR, bed rock.

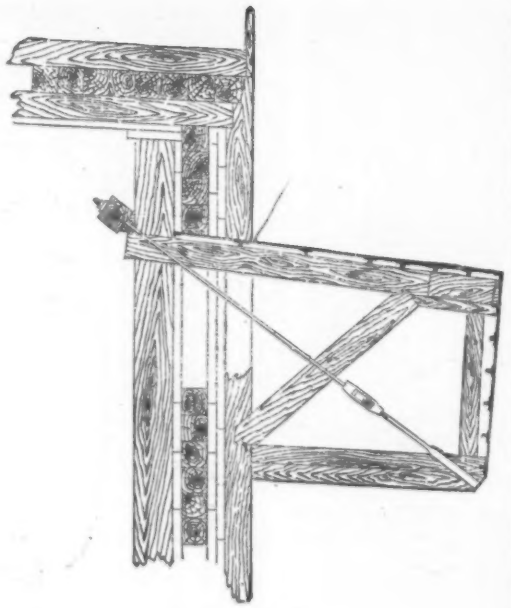
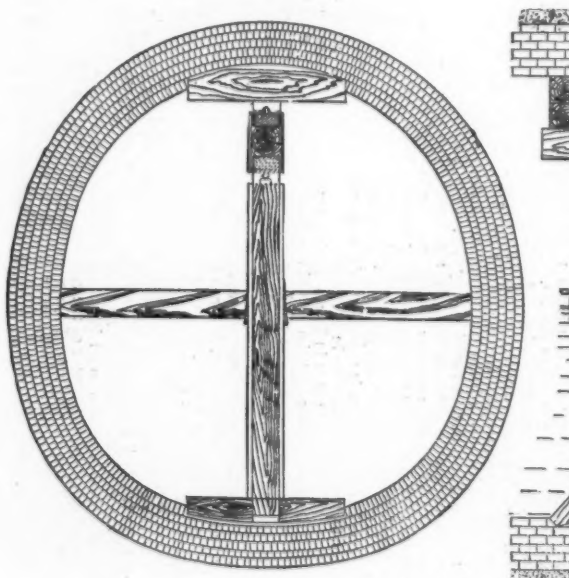


FIG. 3.



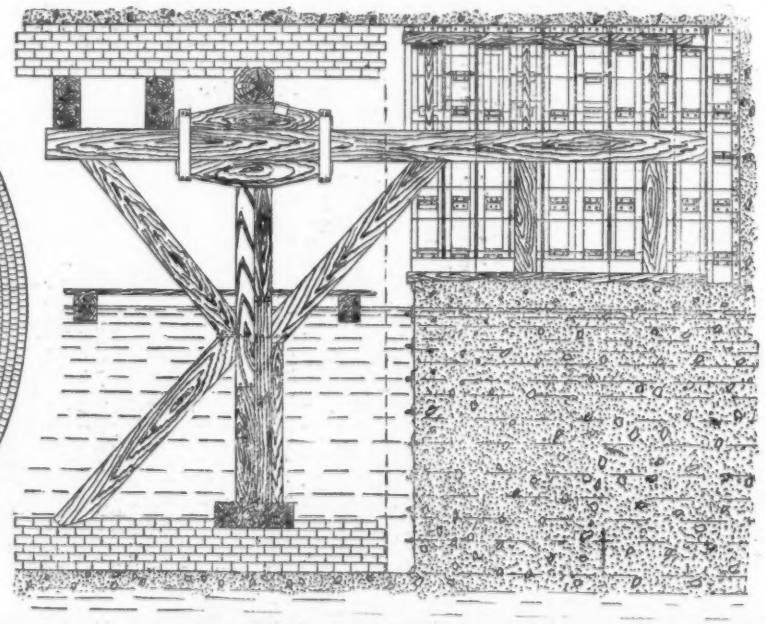


FIG. 2.

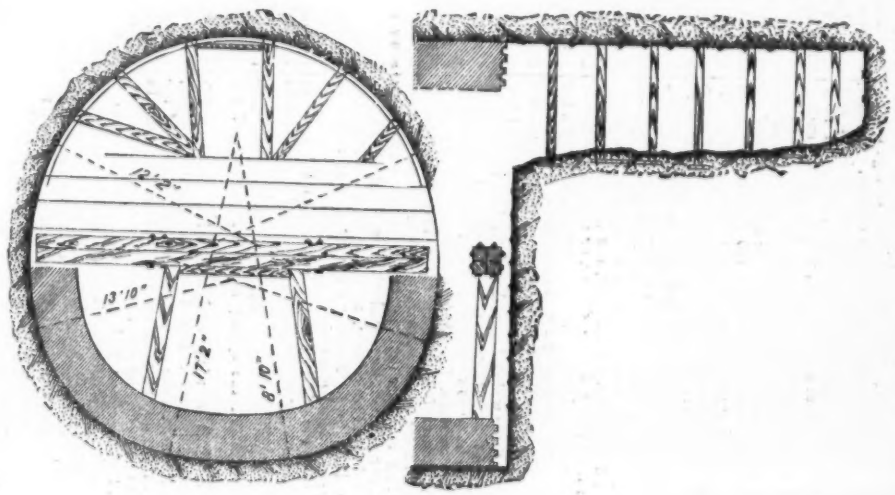


FIG. 4.

THE HUDSON RIVER TUNNEL.—NEW YORK WORKS.

average depth from 10 to 12 fathoms, at a distance of 10 feet from the shore, was discovered. The soi' was scanty, and seemed formed almost entirely of large black pebbles of a sandy nature. Between these grew a green and thin-bladed grass, resembling very much the wood-lick grass of the Eastern States. The island is a flat table land. As the sailors went toward the center, they came upon numerous ponds and marshes of brackish water. The only vegetation seen was a small, pinkish, odorless flower, with four petals, and rock moss. Piles of driftwood were discovered everywhere. It was apparent that at some seasons the island is entirely covered with ice. This, it is surmised, was the reason that De Long left no token of the Jeannette on the island There is no probability of a human settlement being effected at any time on Wrangell Land.

THE HUDSON RIVER TUNNEL—THE NEW YORK WORKS.

TUNNELING by compressed air, as illustrated in the subject under consideration, may now be considered as one of the means placed at the disposal of the engineer by which

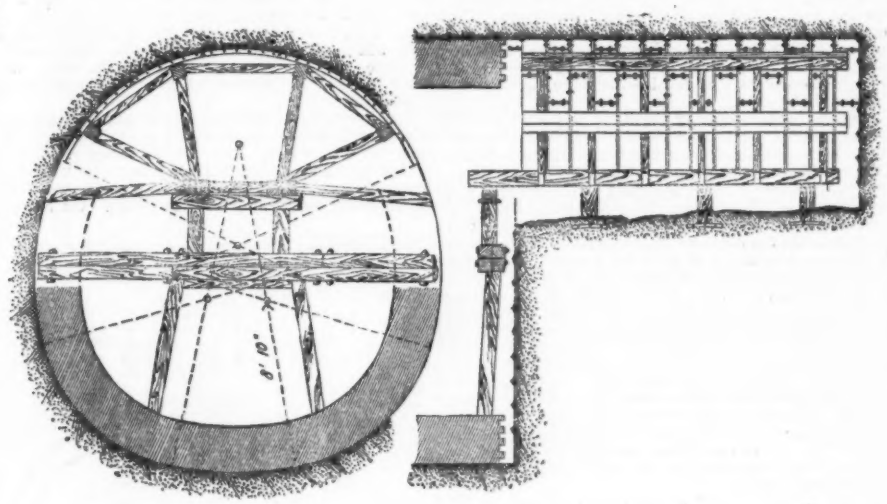


Fig. 5.

he may accomplish his aims. The work already finished, and especially the character of this work, entitles it to this position, even if no further advance should be made. It was a bold innovation upon long-established rules and theories, but in the future its peculiar adaptability under certain conditions will render it of inestimable value. As in the case of many other new plans for doing hard work, the difficulties encountered and overcome could not be anticipated—certain known laws existed which could be made subservient; also certain unknown conditions appeared which the teachings of experience alone could master. Under a combination of these two features, progress could only be made by the exercise of extreme caution and a vigilant watchfulness, ever ready to profit by the outcome of the hour.

Had the tunnel advanced through the same material at all stages, no change would have been necessary in the plans, except such as might be considered as improvements upon those in vogue. But substances have been found which varied widely, and even the same material has been found

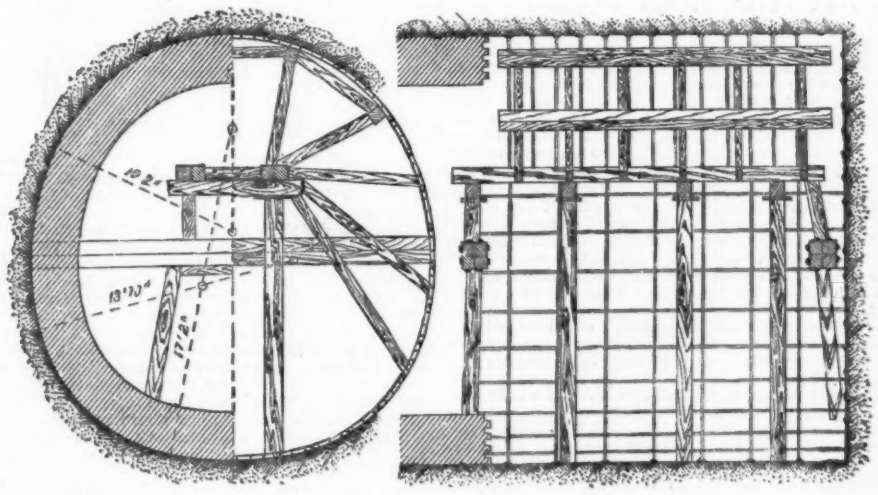


Fig. 6.

which presented many different aspects. This has been particularly noticeable in passing through the silt on the New Jersey side; in general it is so compact as to present an almost perfect barrier to the escape of the air; in the other cases it is so soft as to permit of a much too ready passage of the air. Sand and gravel have been met, and under conditions which have but seldom been analogous. It might, in fact, be stated that in the building of every section of the tunnel, a practically new material has been discovered. That a plan works successfully in one section or instance is no guarantee that it will work equally well in the next, and, as a natural consequence, new methods and devices that would fit the case in hand have had to be thought out.

Another prolific cause of annoyance has been the utter impossibility of estimating, by calculation, the amount of air pressure required for the best interests of the work. A pressure per square inch equal to the hydrostatic head could be readily obtained, but in most cases it would not suit the characteristics. The earth surrounding the tunnel may be considered as an envelope or skin whose minimum thickness is the distance from the roof or arch to the bottom of the river. A variation in the density of this skin, no matter how slight; a difference in the upper vertical thickness; the specific gravity of the mass; the porosity of that portion immediately adjacent to heading; all these circumstances have combined to influence the air pressure requisite, and have compelled its determination by actual trial and experiment, and not by mathematical process. As success depended, in a certain sense, upon a true equilibrium being secured between the confined air and the incessantly changing aspects of the surrounding parts, great nicety was required in the trials; and when the balance was found, it could only be prolonged by attentively noting the alterations and quickly and precisely suiting the pressure to the new feature. When desired, a reduction of the pressure could always be speedily effected, and required no special apparatus; but a rapid increase at some critical stage of the work could only be obtained by having at the disposal of the engineer machinery powerful enough to immediately supply his demands. This he has had, and we find among the permanent plant located near the mouth of the shaft air compressors of large power and of the best patterns.

The tunnel has been prominently before the public for the past two years. Every step of its way has been described in a popular style by the daily press of this city; every new device in the appliances or new method of accomplishing a certain object has been chronicled in the technical journals. The magnitude of the undertaking and the novel plan of construction have combined to render it a most pleasing and profitable study for the engineer, and as there is an inherent curiosity implanted in the majority of men, leading them to inquire as to the when, where, and how a particularly difficult or dangerous work was done, and as these same men have a sort of undefined longing to enter the scientific world, or at least to gaze upon the borderlands, so this topic, whenever treated by the popular press, has found many interested readers. That portion of the commercial world which has at heart the advancement of the business of this port is quietly watching the progress of the work. The financial benefits to be derived from the completion of such a pathway under the Hudson are too manifold and apparent to need even an enumeration.

A glance at a railroad map of New York, showing the termini of roads bringing the produce of the great West, and a brief calculation of the annual value of this traffic, and the at present unavoidable delay occasioned by the river, explain the paramount importance of the work. What would follow a completion, as regards other tunnels, can only be conjectured, yet we have no hesitancy in predicting several.

It has been the endeavor of *Engineering News* to describe and illustrate the work at the time the special methods under consideration were in operation. We have attempted to do this in such a manner that the articles, taken as a whole, would constitute a history of the work compiled from actual observation. In this we have been favored by permission to visit the "heading" whenever it was deemed advisable, and have been most materially assisted by the explanations "on the spot" from the engineers and by the loan of plans to aid us in making drawings. Although we have visited the tunnel at all hours—seasonable and unseasonable—we have invariably been received with that kind courtesy and attention which a reporter, above all men, is best able to appreciate. We this week present to our readers several drawings and a description of the tunnel at

THE NEW YORK WORKS.

The caisson was sunk during the latter part of last year and the fore part of this to its position, shown at K, Fig. 1. It passed through a conglomerate filling, old dock work, which occasioned much delay, dock mud, and finally rested in a bed of sand interspersed with small rock and gravel. The lower portion of the caisson was 48 feet long and 29 feet 6 inches wide; its height was 25 feet, and the sides had a batter of one-half to one, and were 3 feet thick. The top was 46 feet long and 27 feet 6 inches wide. The sides were of unusual thicknesses of timber running in contrary directions, and well fitted and securely bolted together. Vertical and horizontal struts of heavy timber were placed in the interior. A supply shaft and lock (shown at F, Fig. 1) came through the center of the roof. A man shaft was constructed at G, with a lock at the upper end, F. The ascent was made by two ladders, and its size and position were such as to form a safe refuge for the men in case of accident. A timber lock is placed at H. Extending through the center of the caisson and coffer dam is a pipe, whose lower end turns, dipping into the water, and is capped with a screen, and whose upper end is connected with a rotary pump. The discharge is into a box-sewer, leading to the river. The pump is driven by an oscillating engine, receiving steam from the regular boilers, which, together with the air compressors, are in a building about 100 feet from the shaft.

The fact that the caisson was embedded in sand led to the belief among many engineers of high standing that an outlet could not be obtained, and the tunnel started by the system of working by compressed air. Indeed, it has become unsafe to pronounce an unfavorable opinion in regard to any particular piece of work connected with the tunnel; in more than one instance, obstacles, which have seemed to present an insurmountable barrier to all future progress, have been met, conquered, and the work has gone forward. New de-

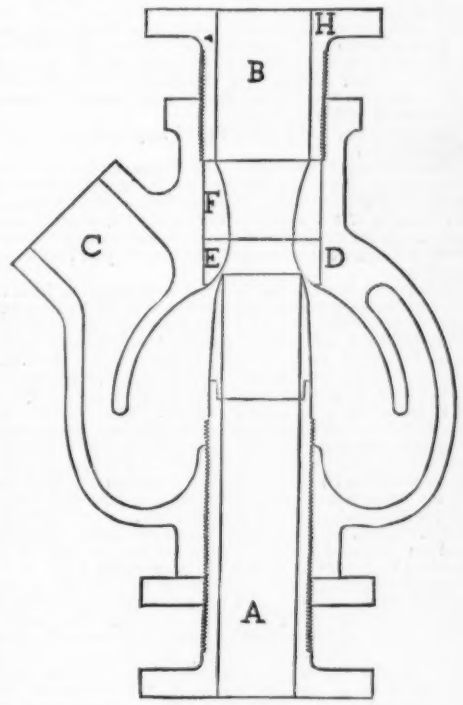


Fig. 7.—Explanation of Letters—A, suction; B, discharge; C, water from pressure pump; D, cast iron; E, chilled cast iron: F and H, composition.

vices and plans have kept pace with new difficulties. At a first glance, the sand above mentioned seemed to contain all the characteristics requisite for a first-class insurmountable obstacle. Upon the least reduction of the air pressure, this material would follow the water into the caisson; the smallest openings afforded a ready passage. The water and sand could be kept quiet as far down as the air pressure was carried and no further, and if a trench were dug, or undertaken, the upward pressure, due to the difference between the air pressure and head of water, or depth of excavation, would fill the trench with sand and water about as fast as it could be taken out, and the adjacent material would then be in no better condition than at first.

Before any work had been done toward opening the heading the following method was believed to be the best under the circumstances. A movable bulkhead or dam, made of oak plank, held at the ends by heading props and by braces from the side of the caisson, or face of completed work—as the case might be—extending from about 6 inches above the invert to the roof or crown plates. The opening at the bottom was left to permit the water to flow from the heading and be pumped away It was expected that considerable would drain away, and that the condition would thereby be improved. Progress was to be made in this way: The air pressure being maintained at about 1½ pounds per square inch more than what would be necessary to keep out water at the crown, the upper plank would then be removed, enough material taken out to admit a plate, when the plank would be moved forward and supported against the next set of props. The next plank would be advanced in the same manner, and so on down to the bottom.

In actual practice iron was substituted for plank, and it is believed that no progress could have been made if this had not been done, from the mere fact that a bulkhead of iron could be made air tight—a thing which was not possible with one of wood. The work of cutting through the caisson may be briefly described as follows:

A score or mark had been made on the inside of the caisson

of the exact form and size of the tunnel at the time of its construction, and no spikes were driven within 6 inches of this mark. After the invert had been finished, men were set at work boring with 2 and 2½ inch augers on that mark, the air pressure being kept at about 18 pounds. As soon as the calking course of 4-inch planking had been pierced, the air escaped in small quantities; but after the augers had reached the diagonal planking between the 12-by-12 timbers, the air rushed out with a loud noise. This was stopped by "blowing" dry cement into the holes whenever the leak was discovered. The blowing consisted in holding a lot of loose cement near the aperture, when the escaping air would carry it into the opening. Usually two or three quarts would suffice, but in the case of the first openings as many barrels were used. Wooden plugs were also provided and a number inserted in the holes after the removal of the augers, but the cement proved convenient, and was generally used. The boring was continued until nearly the entire circumference was penetrated, when the work of cutting out was begun. Owing to the number and arrangement of the spikes, dowels, tenons, etc., employed to fasten each piece of timber, this was a labor of great magnitude, yet patience and perseverance mastered the difficulties. As soon as a hole had been made large enough to admit a plate, it was inserted and held firmly in position by braces. To keep the exposed portion from flaking and falling before the plate could be placed in position, planks were held against it, as described further on. At a distance of 12 feet from the side of the caisson, a bulkhead of iron plates was started at the top, and built down. A system of struts, resting against the caisson, supported this bulkhead, which is put up in regular courses of 15 inches each, the plates being 4 feet in length, except those for the ends of each course, which are cut to correspond with the section of tunnel at the respective courses. It was found impossible to advance a ring of plates of the usual width—2 feet 6 inches—so they were changed to one half this width or 15 inches. This was the first modification or change worthy of note from the practice on the New Jersey side, and although it necessitated more labor, it was advantageous in the increased number of angle bars, in one direction, which nearly doubled the strength. The right thickness of plates is a subject open to much discussion (those used were one-quarter of an inch), and it was maintained by some connected with the work that it could be done without great or unusual risk with plates of any thickness, and that those in use were sufficient, and, being light and easily handled, it was expected by the exercise of skill and judgment in the bracing to hold them in place. It was also found expedient to further reduce the size of some of the plates by cutting the half sizes in two; and finally a few were made only one-eighth the regular size in order to make a closure in unusually difficult ground.

The method of building the tunnel may be briefly summed up as follows:

Making a small excavation and at once setting up an air-tight casing. Each horizontal course is completed before its successor is commenced. This forms what might be termed the segment of the upper part of a cylinder, which is gradually increased until there is a completed circle of plates open to the finished work at one end and closed by an iron wall at the other.

The operation of advancing the iron plates to form the shell was an easy matter so far as the roof plates were concerned—about one quarter of the circumference—although great care and skill were required. The plan was to drive light "poling" strips of ⅛ by 2 inches, and about 2 feet long, directly in front of the last plate put in; the rear ends of the strips were pushed up above and then pulled back so as to rest on the plate already in place. This prevented the material from falling while the excavation was being made. The plate was put in, bolted to the one already in position, and a short brace put up, temporarily, to prevent settling; but it was found that the material on which the lower end of the brace rested was insecure, and systems of A braces, diagonals, verticals with mudsills, etc., were tried, but failed. When the heading had been extended about 12 feet, and the bulkhead put in, reaching across the face of the heading from side to side and down about 6 feet, it was found that the continued settlement of the roof had reached a point where some radical change in the plan must be adopted, or the work would be stopped. The method adopted and which proved eminently successful is shown in Fig. 3. A piece of timber 12 inches square and about 10 feet in length was so placed that one end rested against the outside of the caisson and the other extended into the face of the heading. The forward end was supported from the inside of the caisson by two iron tie-rods, 1¼ inch in diameter, and provided with turn-buckles, thus forming a kind of boom which it was expected would sustain a load of from 50 to 75 tons. An upper member was added to this, and with a strut or two formed a sort of truss, closely resembling a bridge truss. This arrangement constituted, probably, the principal aid in completing the first section.

The system of bracing shown in Fig. 2 was unsatisfactory for many reasons, and was, therefore, supplemented by a better. The drawing shows a transverse and longitudinal section; in the latter the plates have been carried down not quite half way. We produce the drawing to illustrate one of the plans which was tried and found wanting.

The method of building the tunnel as now pursued is clearly shown in the transverse and longitudinal sections, Figs. 4, 5, and 6. Fig. 4 shows the bracing used for about the first quarter of the work: the vertical struts resting upon plates in the sand. In Fig. 5, the excavation has been carried down about half way, and in Fig. 6 the iron shell has been completed and is ready for the masonry. It will be noticed that as the work proceeds the upper course of the bulkhead of the preceding section is removed and forms the lower in the new bulkhead.

After one section had been incased and was ready for the masonry, a quantity of fine sand came in through the joints of the bulkhead, and could neither be bailed nor pumped out. In consequence of this it was impossible to lay brick, and several hours were lost in dealing with it; but after repeated trials without success, and when a concrete invert seemed the only solution, an experimental brick wall, 8 inches thick and about 1 foot high, was built entirely across the forward end of the section. This stopped the flow, and the invert was laid without further annoyance.

At a distance of about 30 feet from the river side of the caisson, an air lock had been put in (F, Fig. 1). This lock is 15 feet long, 6 feet in diameter, and rests on a bulkhead of concrete, I, 6 feet thick. From the bulkhead to the roof, and surrounding the lock, is a wall of brick masonry, 3 feet thick. At the time of the blow-out, last week, the masonry had been about one-half completed in the section which is shown about one-quarter excavated (Fig. 1).

Some two months since, a fire was discovered in the caisson near the roof; wet silt was forced into the opening burned through the 4 inch calking course. This hole was about 4 inches in diameter; the wet silt soon stopped the fire at that point, but in a short time it was noticed that the caisson was getting very hot to the touch over an area of about 3 feet, and serious consequences were threatened. One end of a piece of 1¼-inch pipe, about 4 feet long, was inserted in the hole, and the other placed in a bucket kept full of water. The water was carried into the burning wood work, and the fire quickly extinguished.

A NEW SAND PUMP.

The pump illustrated in Fig. 7, which is a vertical section, was designed by Mr. C. W. Clift, the master machinist of the tunnel. It works upon the principle of the induced current. The water from a pressure pump enters at C, and flows into a globular chamber through the bottom of which passes the suction pipe, A, and passes out at B. The distance between the top of the suction pipe and the points, E and D, can be regulated by the screw, as shown, and any rate of discharge from B can be obtained with little or no trouble. The wear of the pump comes at E, where the sharp sand strikes against the sides. This is made of chilled cast iron, and the adjoining piece, F, of composition. These pieces are cast to fit the pump, and require no adjustment, being held in position by the screw cap, D, as shown. The body of the pump is of cast iron. In actual practice at the tunnel, the pump has been found to give the most satisfactory results—being economical, powerful, impossible to clog, and of easy adjustment and repair—the mere turning of a screw accomplishing both.

The Hudson Tunnel Railway Company was incorporated for the purpose of joining the shores of New Jersey and New York by means of a tunnel under the Hudson River. The Hudson Tunnel Construction Company is now doing the work in the tunnel. The president of this company is Trenor W. Park, of Bennington, Vt.; Mr. D. C. Haskin is manager, and is the most prominent man in connection with the enterprise. In the engineering department, S. H. Finch, C.E, is engineer in charge; E. H. Burlingame, C.E., makes a specialty of the alignment and grades of the tunnel; C. W. Raymond, Mem. A. S. C. E., and J. W. Wolbrect, are assistant engineers on construction; C. W. Clift is mechanical engineer in charge of machinery; M. Nolan, formerly of the Dorchester Bay Tunnel, for the Boston improved sewerage, is superintendent, in place of C. C. Lovejoy, now with the N. Y. O. & W. R. R., as superintendent of bridges and buildings; George F. Seward, ex Minister to China, is connected with the financial department at the works. A large Clayton air compressor will replace the present small one on October 1. The air is now being supplied by two of the Ingersoll rock drill compressors. A small Andrews pump keeps the water in check.

There was a "blow out" at the tunnel on August 20, which happily caused no loss of life, but which has delayed work somewhat. On Wednesday of this week, the removal of a small bowlder was the cause of a loosening of the material in the roof of the tunnel, so that the men were driven out of the heading; but the leak was stopped and the men returned to work within half an hour. On the same day an inroad of the silt drove the workmen out of the Jersey end of the tunnel, but at our visit, on Thursday, we were informed that the leak had been stopped and work was progressing as usual. The engineers explain the trouble as follows:

The silt is held in its position best when at a certain point of saturation; if the air pressure is increased, it drives the water into the silt, which becomes flaky and liable to disintegrate; the difference of one pound of air pressure will cause this change, and from this cause it was that the silt got started on Wednesday, and before it could be "plugged" it filled the heading. The manager and engineers do not seem to fear these mishaps, except that they add to the labor and expense of the work, and also cause delay.—*Engineering News.*

COMPRESSED AIR LOCOMOTIVES.

COMPRESSED AIR FOR PURPOSES OF LOCOMOTION, AS ILLUSTRATED BY THE TRAMCAR SYSTEM EMPLOYED AT NANTES.

By Sir F. J. BRAMWELL.*

I NEED hardly say I am not about to suggest to Section G that it would be a judicious proceeding to suppress on ordinary railways the steam locomotive, and to supply its place by locomotives worked by compressed air forced into reservoirs by steam power. I am aware that a large stationary condensing engine can be worked with much more economy than a non-condensing engine such as is commonly used for small factory purposes. I am also aware that it can be worked with more economy than that which obtains even in a good locomotive developing 200 or 250 horse power, although these locomotives, having regard to their substantial pressure of 150 pounds above atmosphere, and to the very considerable expansion obtained by a link motion well "notched back," do give very fairly satisfactory results; and this being so, there is certainly not enough margin between the consumption per horse power in the best stationary condensing engine and that of a locomotive to compensate for the losses which arise in employing the steam engine to compress the air, and in using that compressed air to propel the train.

There are, however, special cases wherein it would be of great advantage to get rid of certain unpleasant circumstances attendant upon the use of a steam locomotive, even when worked by a coke fire, and still more when worked by coal.

In underground railways, in very long tunnels without ventilating shafts, such as the tunnels through the Alps and the Channel Tunnel, it is very desirable that the train should be propelled without involving the breathing of an atmosphere composed of carbonic acid with a dash of carbonic oxide, sulphurous vapors, smoke, and sparks. There are situations where it is true wisdom to make some sacrifices of fuel economy for the purpose of obtaining immunity from these evils, and in such cases compressed air offers a solution of the difficulty.

Again, where the question is that of mechanical propulsion through crowded streets, which is the kind of propulsion needed for mechanical tramcars, there are certain objections to the employment of steam engines—objections that are very grave indeed, unless great care and circumspection are used, which lead one to consider whether some other source of power is not available; and again, compressed air presents itself as a satisfactory answer to the question "What is an unobjectionable mechanical motor for a tramcar?"

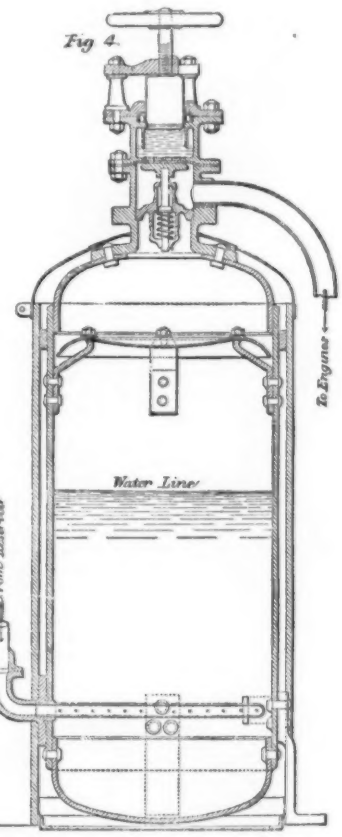
The fact that compressed air can be thoroughly relied on as an efficient method of tramcar propulsion has been established by the successful application of that power for tramcar purposes, which was made in the town of Nantes, now as long since as April, 1879. From that time to the present day the working has been regularly carried on, and it has occurred to me that the details of it may possess sufficient interest for Section G to justify me in occupying the time of the section by a short account of the Nantes compressed air tramways.

I have hung on the wall a diagram, which shows the Nantes Tramway. This begins at Doulon, an eastern outskirt of Nantes; it then runs westerly and southerly along the main road, and then parallel with the wall of the station yard of the Orleans Railway. Here it gets into the busy part of Nantes, and then proceeds along the Quai in a westerly direction, past the Exchange, and through the very busiest part of the town; crossing the railway on a level for the last half mile of its course it strikes a little inland, and runs to the western terminus, Chantenay. The whole length of the line is 3⅞ miles, and for two miles of this the line, as has already been said, is on the Quai, the very center of traffic of an important port and commercial town of 120,000 inhabitants.

There is on an average a departure every ten minutes from each end of the line, for from fourteen to fifteen hours out of the twenty-four according to the season. By an average departure, I mean that at certain hours of the day, when the traffic is greatest, the departure is made at more frequent intervals than ten minutes, while at other hours of the day twelve minutes elapse between the departures.

The Thursdays, Saturdays, and Sundays are the busy days, and on these days as many as 96 departures are made each way in winter, and 106 in summer. The traffic, except on holidays, is carried on by means of "automobiles." These are passenger cars containing their own machinery. Of these the company have twenty-two. On Sundays and

Fig 4.



fête days, however, these are supplemented by two compressed air locomotives, each of which draws after it two imperial cars.

Figs. 2 and 3 show a tramcar now being made under my directions for use on one of the London tramways. It differs somewhat from the "automobile," but is sufficiently like it to enable me to use it for the purpose of explaining the construction of the "automobiles." These carry no passengers on the roof, but they have at the hinder end (they always run one end first) a long platform, on which as many as twelve passengers can stand without crowding. They seat in the car nineteen passengers, and thus their total legitimate load is thirty-one passengers beside the driver and the conductor; but on Sundays the passengers press into them without any other limit than that of the inability to wedge any more in. Under these circumstances, no doubt, as many as forty to forty-five passengers are carried, and probably more.

The gauge of the line is 4 ft. 8½ in., and the wheel base is 5 ft. 9 in. The wheels are 2 ft. 4 in. in diameter. The cylinders, which are at the forward end, are outside, and the connecting rods lay hold of crank pins in the leading wheels. The leading and tender wheels are not coupled. The cylinders are 5⅜ in. in diameter by 10¼ in. stroke. The air is compressed to 450 lb. above atmosphere, and is carried in ten cylindrical steel vessels supported in the underframing which is of wrought iron. These vessels have an aggregate capacity of 99 cubic feet. About two-thirds of this storage is coupled up together, and is known as the "battery," while the remaining third, which is coupled up separately from the two-thirds, is known as the "reserve."

At the front end of the "automobile" there is a vertical vessel which, when the car is being charged with air, is itself charged with steam and water at a pressure of about 75 lb. above atmosphere. The air on its way from the "battery" (or the "reserve" as the case may be) is caused to bubble up through this water, and thus becomes heated so as to increase its volume and useful effect, and so as to enable it to be expanded in the cylinders without risk of the formation of snow.

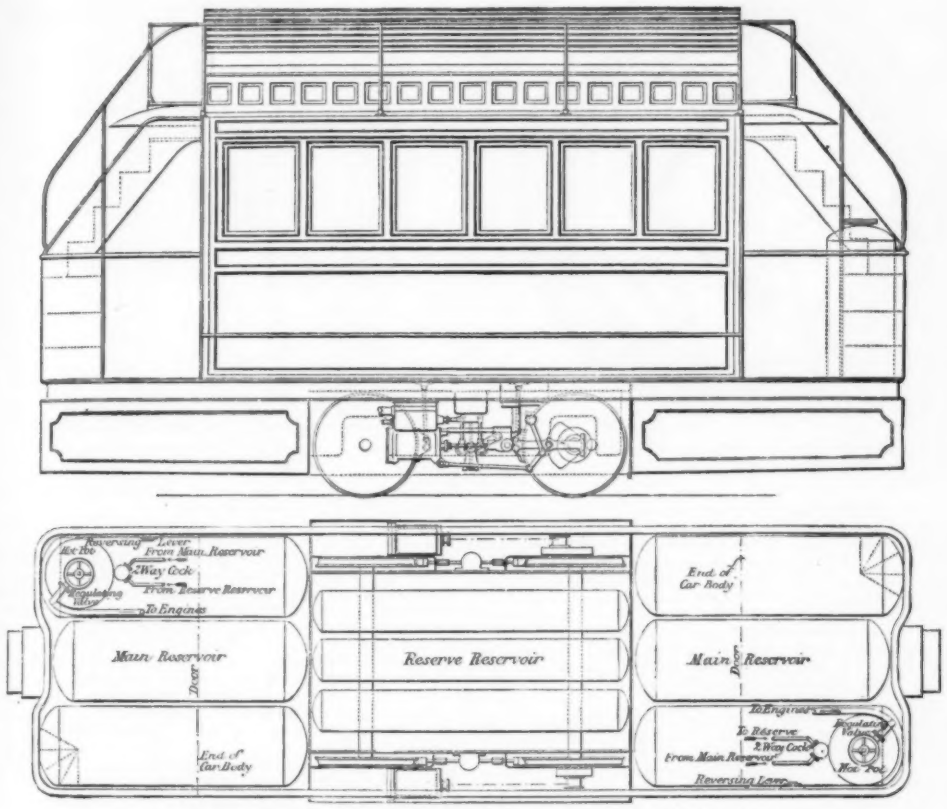
The regulating valve is put on the top of this vertical

* Paper read before the Mechanical Section, Southampton meeting of the British Association.

vessel. This valve is of peculiar construction, as shown in Fig. 3. It will be seen that the hand wheel when turned lowers or raises a plunger; this acts upon the liquid contained between the diaphragm placed a little below the plunger and the upper part of the vessel. Just around the plunger there is an annular air space acting as an air vessel. When the plunger is depressed into the liquid, the result is to compress the air in the air vessel to any desired extent. Then, on the air cock being opened, air bubbles through the hot water, and rises past the cone valve, which is attached to the diaphragm into the space below it, so as to press on the underside of the diaphragm and tend to raise it; but it cannot succeed in doing so until the pressure of the air below the diaphragm equals that in the annular air vessel above, and thus the pressure in the annular air vessel is done, the compressed air connection and the steam connections are being made.

The connections consist of copper pipes bent into one or two turns of a helix, so as to give some elasticity. These, by means of unions at their ends, are coupled to the fixed valves, and to the valves of the "automobile." The valves are opened and the air is charged in, while the steam is sent up through the water which remains in the "hot pot." Six to eight minutes suffice for this operation, but ten minutes are an excess allowance.

At the depot at Chantenay the engines are only half the size of those at Doulon, and there are only two of them. I was enabled to take indicator diagrams from the engines and the pumps, and I was surprised to find that as much as 82 per cent. of the gross indicated horse power in steam



MEKARSKI'S COMPRESSED AIR TRAMCAR.

automatically the measure of the pressure that will prevail in the engines. So soon as this is exceeded the diaphragm rises and closes the valve; and so soon as it falls the air in the annular air vessel re expands and lets in more compressed air. In this way the driver can, from time to time, vary the pressure by his handwheel, confident that whether the engines are running quickly or slowly, that pressure will be steadily maintained. The automatic regulating valve and the employment of the "hot pot" are the distinguishing features in this particular system—the Mekarski system—of using compressed air. There is an air brake acting on wedges between the wheels; this is put on by a continuation of the same movement of the handle that shuts off the air from the cylinders. The engines are inclosed in a pair of cupboards, and being of the outside cylinder type every part is at once seen, and is accessible when the cupboard door is open. The slides are each driven by a pair of eccentrics carried on a return crank. These work a link motion, and the driver has the usual spring catch-lever and sector plate to reverse and to "notch back." He has also a mechanical horn to give warning of his approach.

These "automobiles" are under the most complete control. I found after a very short observation that I could drive without any difficulty, and, as a matter of fact, they stop to pick up and set down passengers just as a horse tramcar would do. Nothing can be more satisfactory to the passengers and to the public generally than the performance of these "automobiles." There is no smoke, no smell, no puffing, no escape steam. The exhaust air is let into a box between the engines, and from this escaping quietly just above the level of the road. The impression conveyed to the mind on first seeing one of these "automobiles" is that an ordinary horse car has been allowed to run away down a hill of a sufficient gradient to keep the car in motion. The mode of working is to use the "battery" only when on the level, and to keep the "reserve" for a bad bit of road, or for a rise over some bridges which have to be traversed, and thus, although the pressure in the "battery" may be getting low when nearing home, the "reserve" is always there to aid over a difficult place.

The locomotive is able to make the journey out and home, 7¾ miles, without needing any replenishment of the air, but the "automobile"—which on reaching the termination of its outward journey has had the pressure in the "battery" lowered from 30 atmospheres to 12 atmospheres (the "reserve" being intact)—takes in a partial charge, raising the pressure in the battery to 22 atmospheres.

The principal depot is at Doulon, where there is an engine-house containing four horizontal condensing steam engines, each of about 20 nominal horse power with cylinders of 1 ft. 9½ in. diameter, by 3 ft. 3⅜ in. stroke. Each of these engines has alongside of it a bedplate similar to that of the engine, and on this are fixed, tandem fashion, two air pumps. These are single-acting. The first pump compresses from atmospheric density to six atmospheres absolute, while the second draws from the first and compresses to 30 atmospheres absolute. On the arrival of an "automobile" opposite the depot it runs on a turn table and is then driven into the filling shed. This is alongside the engine-house, and in the partition wall are fixed six sets of filling pipes with their stop-cocks. A certain quantity of the water is run out of the "hot pot," and while this is being piston reappeared in the pistons of the compressing pumps, so that the friction of the engine, the power absorbed in working its condenser air pump, and the friction of the compressing pumps only amounted to 18 per cent. of the total gross indicated horse power.

I had no means of obtaining diagrams from the engines of the "automobiles" themselves, and I cannot therefore tell the Section what was the power given forth by the compressed air engines. I have little doubt, however, but what there was a very considerable percentage of difference. The compressing pumps, instead of discharging directly into the reservoirs in the "automobiles," and being thus resisted by the gradually increasing pressure in these reservoirs discharge through a valve loaded to the maximum pressure into reservoirs fixed in the engine-house, and maintained at about 22 atmospheres. This arrangement is made to shorten the time of charging, but it appears to me it could well be dispensed with in a large establishment where the "automobiles" could come in succession to be supplied. Again, in the "automobile" itself, no means exist of varying the expansion to such an extent as to utilize the full pressure of air when the "automobile" starts on its journey. One-half of the engine's power is "stand-by" power, as it does not need even two of the engines to run constantly to do the work. It would appear, however, from the information given to me that the cost is somewhat less than that of horse power, and if this be so, then on various grounds the compound air system is to be preferred. It is cleanly, it is trustworthy, and above all it does away with the fearful waste of animal life. I am afraid it is but too true that the horses employed in tramcar work are but short-lived. There is nothing that can be pointed at from day to day as any evidence of cruelty, but the broad fact remains that the animal dies before one-half or even one-third of the natural term is accomplished. This is a shocking thing to reflect on, and I am sure that all would rejoice in the substitution of mechanical traction for animal traction obtained at so painful a sacrifice.

I am glad to say that one of the metropolitan tramway companies is about to try the Mekarski compressed air system on a road (the Caledonian Road) which runs from King's Cross to Holloway. The drawing exhibited is that of the compressed air car which is being made for this service. As it is not possible to put turn-tables in the public road at the King's Cross end of the journey it has been necessary to construct this car so as to run either end first, and thus the long standing platform at the rear end of the Nantes "automobile" has been suppressed, and the passengers who at Nantes stand on this platform are in London to be carried on the roof.

The engines also have been removed from the end of the under frame and placed in the middle. The Board of Trade limitation of extreme width made it very difficult to obtain space for working the link motion by means of eccentrics placed on a return crank; and I was very glad to be able to avail myself of the extremely ingenious valve gear of Mr. Joy, where (as is, I think, well known to most of the Section) the motion is obtained from the connecting rod, and is therefore in the plane of the center of the cylinder.

SCHWARTZKOPFF'S SAFETY APPARATUS FOR STEAM BOILERS.

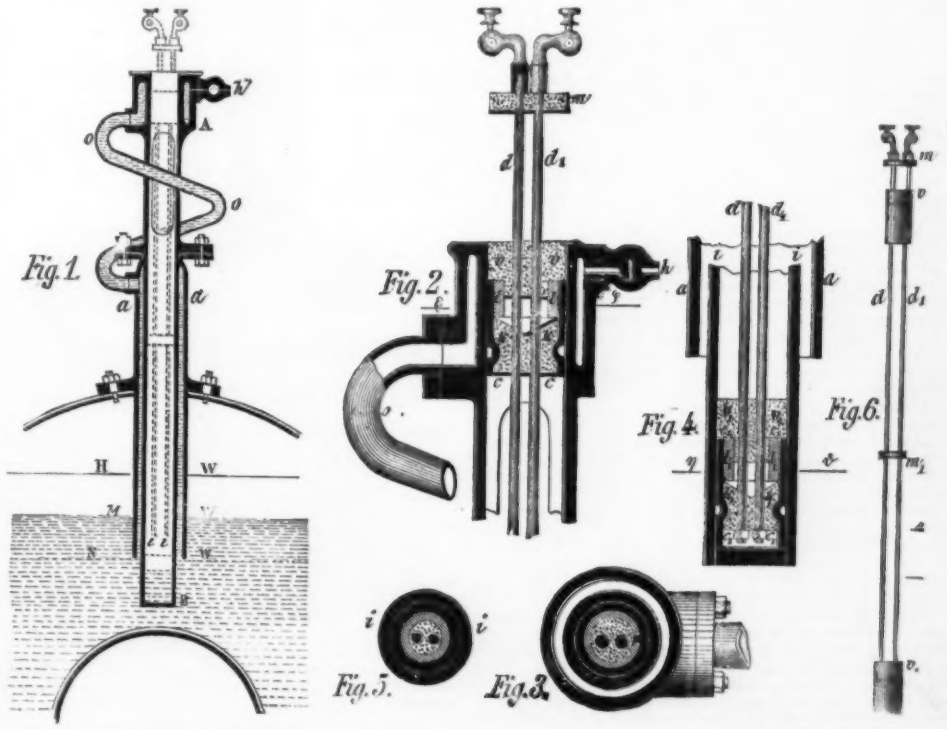
THE object of the apparatus shown in Figs. 1 to 6, invented by Mr. Schwartzkopff, of Berlin, is to give a signal that shall be visible and capable of being heard—first, when the pressure of steam exceeds a certain limit; second, when the level of the water descends below a definite point; third, when the water in the boiler reaches a temperature higher than that that corresponds to the proper pressure of the steam; and, fourth, when the boiler is heated while it contains no water.

In the first and second cases, then, it controls the safety-valve and the pressure-gauge or the water level; in the third, it indicates a retarded ebullition; and, in the fourth, it is arranged so as to act before the boiler plate can be damaged.

The principle upon which the operation of the apparatus is based consists in actuating an electric alarm signal by the melting of an alloy, which, when it is melted, closes the circuit and establishes a contact between the extremity of two copper rods. The alloy is employed in the form of hermetically inclosed rings, upon which acts the heat of the water or steam, or that which radiates from the sides of the boiler in case a fire is lighted under it when it contains no water.

As shown in Fig. 1, the apparatus consists of two concentric metal tubes, *a* and *i*, the inner one of which is closed at the base and open at the top, and is fixed hermetically to the outer one by means of a flange. The external tube is screwed or riveted by its flange to some suitable part of the top of the boiler. It is open at the base and extends into the boiler as far as the lowest level admissible for water, while the inner tube extends down still further to within about 1¼ centimeters of the highest part of the surface of the fire-place or flues licked by the flames. Between the two tubes there is a free annular space of about 1¼ centimeters.

The same arrangement of concentric tubes with free annular space between them is repeated at the upper part of the



SCHWARTZKOPFF'S SAFETY APPARATUS FOR STEAM BOILERS.

apparatus, A; and the two parts are connected by a helicoidal tube, *o*. The purpose of this interruption in the annular space between the two tubes is to cool the upper part to a temperature less than that of the boiler. The apparatus, being fixed as shown in Fig. 1, completely closes the boiler, thus allowing of a control of the apparatus so as to cause it to operate, or so as to adjust it after operating, without the escape of water or steam, or without the necessity of interrupting the work of the boiler.

The internal tube, which is of brass, is traversed through and through by two strong nickeled copper rods, *d* and *d'*, which are fixed in several serpentine plugs serving to isolate them, and the upper and lower of which, *k* and *k'* (Figs. 2 and 4), contain cone-shaped depressions, and are surrounded by thin copper coverings that exactly fit in the inner tube. These rods, as may be seen in Figs. 1 and 2, are prolonged outside of the apparatus and provided with binding-screws for connecting them with the electric alarm, the pile, and the signal. They constitute, along with their serpentine plugs and their jackets, a whole that may be easily introduced into the inner tube, or taken out again when occasion requires.

Into the two copper coverings, *c* and *c*, there are fixed two split rings, *l* and *l'*, of alloy, which through their elasticity press against the inner surface of the former. The coverings are closed hermetically by two serpentine plugs, *v* and *v'*, which slide on the rods and prevent all external influence of the steam, air, and water. The alloy rings are compounded in such a way as to melt at definite temperatures. The upper one melts at the temperature of boiling water, and the lower one at a temperature slightly exceeding that corresponding to the maximum pressure of steam compatible with the security of the boiler.

The upper extremity of the external tube is fixed to a small cock, *h*, which permits of disengaging the air contained in the annular space at the moment of putting in pressure. The annular space must always be filled with water up to the top. As this water does not circulate, and as the helicoidal tube allows sufficient heat to radiate, the upper part of the apparatus remains always relatively cold as long as it is full of water. The air that it might contain, although it would not prevent the operation of the apparatus, might sometimes retard it.

The apparatus begins its action under one or the other of the following conditions:

1. The alloy of the copper melts and sets the alarm ringing as soon as the water lowers in the boiler slightly beneath the minimum level admissible; because the water in the annular space falls into the boiler and is replaced by steam, which heats the upper part of the apparatus to a higher temperature than the fusing point of the ring.

2. The alloy of the lower ring melts as soon as the pressure is reached or exceeded that corresponds to the maximum pressure admissible. This happens (1) if the pressure of the steam exceeds the limit fixed, and (2) if the water becomes heated to a dangerous degree without the pressure increasing in proportion

3. When the boiler is heated when it contains no water, the heat radiated from the iron plate causes the apparatus to operate.

In these cases, the molten metal runs into the hollows of the serpentine plugs and sets up a contact between the two copper rods, thus actuating the electric alarms connected with the latter. As has been remarked above, the apparatus gives its signal without disengaging steam or water; and, after it has operated, the rods may be easily taken out, the molten metal be removed, and new rings be put in without in any way interrupting the operation of the boiler.

THE HISTORY OF MAGNETO AND DYNAMO ELECTRIC MACHINES.

By AUG. GUERONT.*

SCIENTIFIC journals have on several occasions, in recent times, raised questions of priority in regard to magneto and dynamo electric machines, and the information given has permitted of the elucidation of certain points in the history of these, at present, so important apparatus.

A similar research into the rights of each of them will not be without value at the present time, when inventions are multiplying on every side with so much rapidity; so it has seemed to us that it would be of interest to bring together in this place such documents as have been brought to light by journals, or through the presence at the electrical exhibition of certain apparatus, and to make these complete by the information that we ourselves have been able to gather, so as to form a brief history of the development of magneto and dynamo electric machines.

In this study we shall consider these machines from their origin; but we shall stop at the first ring machines, starting from which we leave the historical portion of the question to enter the domain of present practice.

To take induction machines at their very origin, it is necessary to go back to the fundamental experiments of Faraday,† which were performed with apparatus that might have been seen at the Palais de l'Industrie. After ascertaining the induction produced in a helix by another helix traversed by a current, Faraday studied the induced currents that resulted from the magnetization and demagnetization of iron. The first apparatus by means of which he demonstrated such currents deserves to fix our attention.

Around a soft iron ring (Fig. 1) of about 2 centimeters thickness by 15 centimeters diameter, he wound at A three layers of insulated copper wire, capable of being united for tension, or for quantity, or for operating isolatedly.

At B, he likewise wound wire, but in less quantity, leaving between the two windings, at two extremities of the same diameter, almost a centimeter of naked wire. On connecting the wire, B, with a galvanometer, and one of the solenoids of A with a pile, he ascertained by the galvanometer that a current was produced at the moment the circuit was established and broken. The same result was obtained more clearly by dividing the wire of A into two helices, one of which was connected with the pile, and the other with the galvanometer.

Finally, on uniting in tension the three spirals of A, and connecting them with the pile, and then terminating the wires of B with charcoal, as shown in Fig. 1, he obtained the first induction spark, and ascertained that it was always produced at the moment the current was established, and rarely when it was broken.

Among his other arrangements must also be cited that in which a wire wound around a soft iron cylinder became the seat of a current when it was applied to the poles of a horseshoe magnet, or removed therefrom. Apropos of this, Faraday made in a note the following remark: "A bar of soft iron, forming the armature of a horseshoe magnet, and carrying at its center a wire bobbin, furnishes, when it is applied to the magnet, a means of producing a short but notable electric current." The arrangement shown in Fig. 2, and which constituted a portion of the Faraday apparatus, gives a practical realization of this idea put forth by the illustrious scientist at the beginning of his researches, and may be regarded as the germ of apparatus of the kind called *coup de poing*, a large number of styles of which have since been constructed.

Faraday's experiments had scarcely become known when efforts were made on various sides to apply his results to the practical production of the electric current.

The first reference to a machine constructed for this purpose is found in a letter addressed to Faraday, July 26, 1832.

FIG. 1.—FARADAY'S APPARATUS FOR EXPERIMENTING ON INDUCED CURRENTS.

This was signed simply with the initials "P. M.," and contained a description of a magneto-electric machine that had served its inventor for decomposing water. This letter was sent to the *Philosophical Magazine*, and was published therein in the number for the 2d of August, 1832. The apparatus consisted of a wooden disk containing six equidistant slits, into which were set six iron horseshoe magnets. Of these latter, which were placed perpendicular to the plane of the disk, the poles projected on one side, and the line of the poles of each of them ran in the direction of the radius of the disk. Besides this, the poles of each two consecutive magnets were, as regards their polarities, arranged in directions opposite to each other. The disk was capable of revolving in a vertical plane before six stationary soft iron armatures, surrounded with insulated wire. This wire was wound alternately in one direction and the other, so that there were obtained at the same instant currents of the same direction in all the armatures.

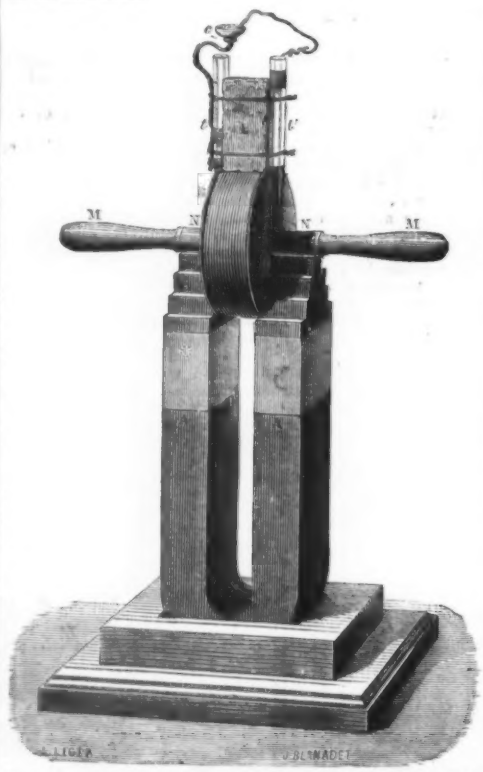


FIG. 2.—EARLY APPARATUS OF FARADAY FOR THE STUDY OF INDUCED CURRENTS.

It is certainly interesting to see that there was employed at a date so remote a mode of winding of the induced parts which is found in almost all alternating machines now; but the anonymous originator of the apparatus did not judge proper to produce it in public, and the first electro-magnetic machine that was seen to work publicly was that of Hippolytus Pixii, which was presented before the Académie des Sciences by Hachette, September 3, 1832, and which was operated the same year in Ampère's course. It consisted, as well known, of a horseshoe magnet that revolved before the poles of an electro-magnet of the same form, and gave alternating currents. It is too well known, however, to make it necessary to reproduce a figure of it in this place.

RITCHIE'S MACHINE.

The oldest machine, after that of Pixii, was one that Ritchie presented before the Royal Society of London, March 20, 1833. In Fig. 3, we reproduce the sketch of it that the originator gives in his memoire. In this apparatus, four bobbins, *r r*, are mounted on iron cores, which are supported by a revolving frame, *a b c d*. These cores present themselves successively before the poles of a magnet, M. The wires designed for collecting the current start from mercury cups, *m m'*, that are connected with annular plates, *g h* and *e f*, against which rub the extremities of the bobbin wires. In his memoir, Ritchie says that his machine was partly finished nine months before it was possible to fully complete and describe it. He seems thus to have a desire to

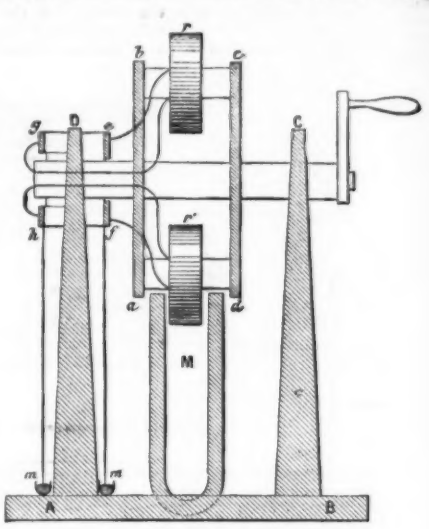


FIG. 3.—RITCHIE'S MACHINE.

establish the fact that his apparatus antedated Pixii's; but the priority is more than doubtful.

SAXTON'S MACHINE.

Shortly after this machine was made public, there was exhibited, in June, 1833, at the meeting of the British Association, at Cambridge, Saxton's machine, a copy of the original design of which we give in Fig. 4. As may be seen, this machine consists of a stationary iron horseshoe magnet, before whose extremities revolve four induced bobbins. The two extreme wires end, one in a small wheel, E, and the other at a point, F, each revolving in a mercury cup. The Saxton machine remained on exhibition from the month of August, 1833, at the Gallery of Practical Science, in Adelaide street, London; and, at this epoch, Faraday, Daniell, and Wheatstone made allusions to it on several occasions in their memoirs. Saxton described it, however, only in 1836, in the November number of the *Philosophical Magazine*, after this same journal had published, in its October number, a letter signed Edward Clarke, magnetician.

CLARKE'S MACHINE.

In this letter Clarke described a magneto-electric machine, the fruit, said he, of a long and costly labor. Saxton at once sent to the *Philosophical Magazine* a description of his machine, and which, at the same time, was a claim for his rights. He treated Clarke therein as a counterfeiter, not because he had constructed the instrument, which was something that he recognized every one had the right to do, but because he had given it as his invention, and had omitted all mention of the name of the true inventor.

Clarke's machine is well known. It differed from that of Saxton in the arrangement of the magnet relative to the bobbins, the latter being only two in number. The interrupter also was constructed differently from that of Saxton.

POHL'S MACHINE.

At this point there comes in a curious machine which was invented by Pohl. We find the description of it in the

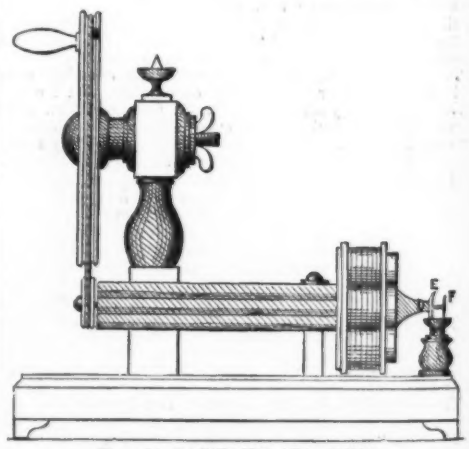


FIG. 4.—SAXTON'S MACHINE.

Annales de Poggendorff, vol. xxxiv., for the year 1835, pages 185 and 500. There are two horseshoe electro-magnets placed opposite one another in the same position as the magnet and the electro of the Pixii machine. These are both stationary, but the upper electro, which is surrounded by a coarse and short wire, receives a current from a pile, of which a tilting commutator, moved by a pulley and eccentric, continuously changes the direction. There result from this, in the finer wire of the lower electro, alternating currents. These latter are sent in one direction by a second commutator like the first, and moved by the same parts. This machine, which was evidently suggested by the preceding, and especially by that of Pixii, rather approaches, however, as to principle, the induction coil, and we do not think that it can be considered as presenting for the first time the use of electro-magnets as inductors.

* From *La Lumière Electrique*.

† "Philosophical Transactions," 1832, p. 125.

Pixii's machine gave alternating currents, and contained only one interrupter designed for producing the spark,* and it was the same with those of Saxton and Clarke, and there is found in the original memoirs no description of the commutator that has since been adapted to them. We find this commutator mentioned for the first time, in connection with magneto-electric machines, in a memoir by Dove, published in 1842. In this memoir the author describes certain additions made by him to a Saxton machine in view of special experiments; and, among these, is found the commutator shown in Fig. 5, and which will be understood by an inspection alone of the cut.

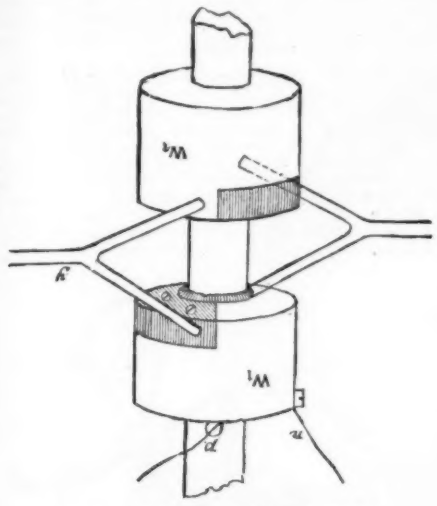


FIG. 5.—DOVE'S COMMUTATOR

We shall not dwell upon the other different forms of magneto-electric machines, such as those of Page, Wheatstone, and Ettinghausen. Those of Stohrer are more interesting, because he was the first (in 1843 †) to construct machines containing more than four induced bobbins. His simple machine was an improvement on that of Saxton, whose general appearance he had preserved.

STOHRER'S MACHINE.

His compound machine (Fig. 6) presented six bobbins revolving before three vertical magnets forming a hexagon. It was provided like the former, moreover, with an eccentric commutator. It is well known that machines having a large number of bobbins were developed afterward by the labors of Nollet in 1849, and the construction of the Shephard machine

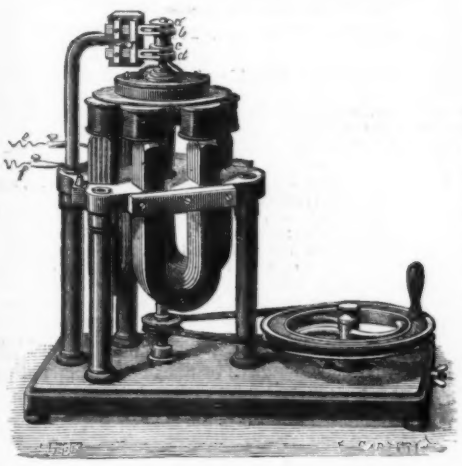


FIG. 6.—STOHRER'S MACHINE.

(1856), modified by Van Malderen and known under the name of the Alliance. This machine, and analogous ones constructed in England by Holmes, demonstrated the possibility of producing by the aid of mechanical power an electric current utilizable for industrial applications, and particularly for electric lighting. They were, besides, the starting point of the present alternating machines, upon which we have no intention of expatiating here.

SIEMENS' DOUBLE T IRON ARMATURE.

But the most important progress made in magneto-electric machines was perhaps the substitution of the long bobbin for the ordinary induced ones, and known under the name of Siemens' double T iron armature. This bobbin, which was placed in a sort of tunnel of magnets forming two longitudinal poles, constituted one of the most practical of machines (Fig 7), and one which at once found a large number of applications. The Siemens armature possesses a further interest in that it became one of the essential parts of those subsequent machines that have exhibited, as to principal progress, first, the use of electro magnets as inductors, then the excitation of such electros by the current itself of the machine, and the utilization for the priming of remanent magnetism machines of the pieces of iron composing them; and it is interesting to seek the origin of these various improvements.

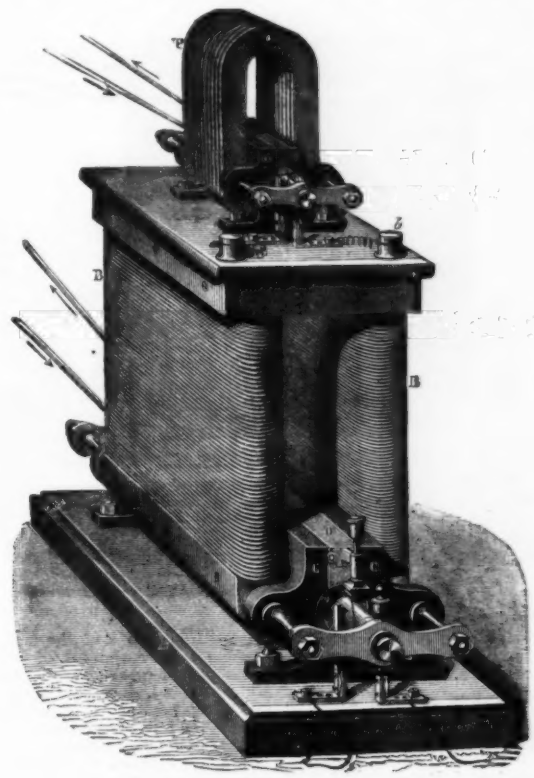


FIG. 8.—WILDE'S MACHINE.

SINSTEDEN'S MACHINE.

The use of electro-magnets excited by a magneto-electric machine, as inductors, appears to have been mentioned for the first time by Sinsteden in a memoir published in 1851 in the *Annales de Poggendorff* (vol. lxxxiv, p. 181). This memoir is devoted to a description of a machine of the Clarke kind having a single magnet and four bobbins, and the author studies the position of the bobbins at which the maximum current is produced, and points out the use of expanded poles for prolonging the motion of the bobbins in front of them.

After describing the effect produced upon an electro-magnet by the current from this machine, Sinsteden says (p. 186):

"I cannot avoid remarking that the permanent magnet of my apparatus, of a constant carrying power of 200 livres (about 268 lb. Troy), produces an induction current which, acting upon an electro magnet, communicates thereto a carrying power of more than double that of the latter. This fact is remarkable enough of itself, but it seems also to furnish a means, in starting with a *single permanent magnet*, of increasing magneto-electric currents to a prodigious degree. Let any one revolve, in fact, before the poles of such an electro-magnet, excited by a magneto-electric machine, four induced bobbins whose cores and spirals are proportioned to its carrying power of 500 livres, and he will obtain by the aid of these four bobbins a current whose intensity will, in all probability, be at least double that of the first current, and he will consequently be able by means of such current to disengage 6 cubic feet of gas per minute in the voltameter, and communicate to an electro-magnet of suitable size and carrying power of 1,000 livres. There is nothing to prevent the revolution before this second electro-magnet of four suitable induction bobbins whose current shall excite a third electro-magnet, and then to place new induction bobbins before the latter, and to proceed thus as long as we remain master of the mass and weight. In this way we shall very promptly obtain induction currents that will leave very far behind them the gigantic hydro-electric apparatus of Childern and Hare. To produce them would cost nothing more than the power necessary to set in motion the revolving bobbins; and, as electro-magnets do not change poles, and as they remain on the contrary constantly magnetized, the coercive power of the iron, and the reaction of the latter upon the spiral, or of this upon the iron, would cause no disturbance. Such magneto-electric currents, thus carried to an enormous intensity, might be employed for motors in place of costly hydro-electric currents over which they would have the important advantage of necessitating no expense such as follows the use of zinc and acids."

THE WILDE AND HJORTH MACHINES.

The idea put forth by Sinsteden seems, however, to have passed unnoticed, and to have attracted attention only when it was presented anew by Wilde in 1864,* in the form of the machine shown in Fig. 8, and in which a small Siemens machine, placed above the inductors, excites the latter.

As regards the excitation of inductors by the current itself of the machine, the first information that we have of it is found in a patent taken out in 1854 by Soren Hjorth, a Danish physicist, whose electro-magnetic motors attracted a good deal of attention at the London Exhibition of 1851, and gained him a grand medal.

In his first patent, dated October 14, 1854, No. 2,198,† and relating to a machine of the Alliance kind, Hjorth says:

"The principal feature of this machine consists in the application of one, two, or several permanent cast iron magnets of the form indicated (in the figure annexed to the patent), in connection with as many or more electro-magnets of the form shown in the drawing, *in such a manner that the currents induced in the bobbins of the revolving armatures shall be made to pass around electro-magnets. Consequently, the more the electro-magnets are excited in the said way, the more the armatures will be excited*, and the more electricity will there be induced, therefore, in their respective bobbins; and, while a mutual and accelerative force is thus produced between the electro-magnets and the armatures, an additional or secondary current is at the same time induced in the wires of the electro-magnets by the motion of the armatures, the said current being in the same direction as the primary current after its passage in the commutator."

The following year, the same inventor patented, under date of April 11, 1855, and under number 806, a similar machine on the subject of which he expresses himself thus in his patent:

"Different attempts have been made to produce electricity by means of armatures brought successively into the field of action of permanent magnets. My present invention consists of certain improved arrangements for producing electricity in large quantity and of great intensity by such means. With this end in view, a series of armatures placed on a wheel revolving at slow speed are brought successively between the poles of permanent magnets and the poles of a series of electro-magnets, surrounded with spirals or bobbins

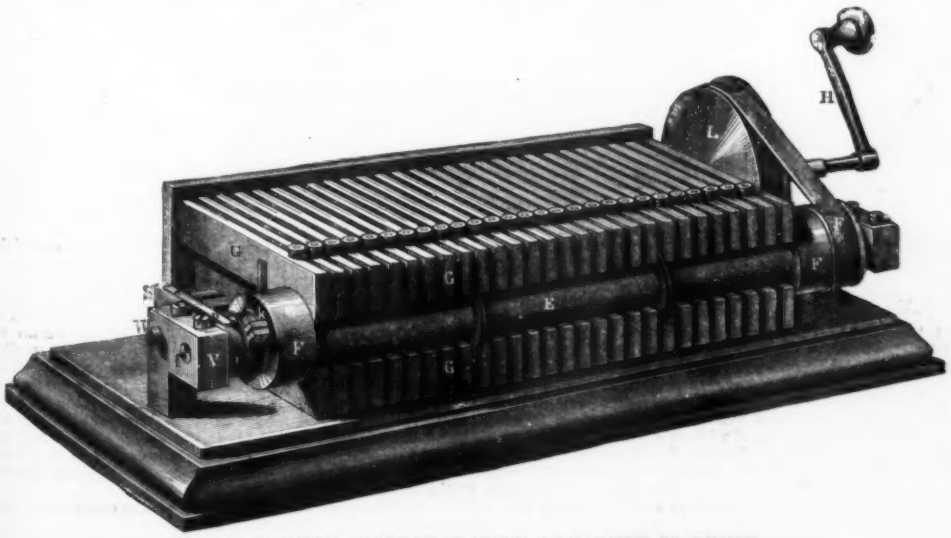


FIG. 7.—SIEMENS' DOUBLE T IRON ARMATURE MACHINE.

*There was soon adapted to it, however, an oscillating commutator of the kind styled "bascule d'Ampere," and actuated by the motion of the machine itself.

†*Annales de Poggendorff*, vol. lxi. (1844).

*His patent is dated the 31st of May of that year.

†See *Engineering* for Nov. 25, 1881.

of copper wire, in the interior of cylinders that are also surrounded with wire. . . . The action of the apparatus is as follows:

The permanent magnets, acting upon the armatures which pass successively between the poles, induce a current in the bobbins of the armatures; *and this current, after being brought to the same direction by the commutators, passes around electro-magnets, charges them and acts upon the armatures.* Through this mutual action between the electro-magnets and the armatures, we obtain an accelerative force which has for a result the production of electricity in quantity and intensity greater than has hitherto been effected by any similar means."

Hjorth's machine was, then, indeed, one superexcited by the current itself, but the first departure (for which at present the *remanent* magnetism of the iron of the electros is used) was due to the permanent magnets entering into its construction.

Hidden in a country a little outside of the circle of scientific movement, the Hjorth machine, like the idea put forth by Sinsteden, passed unperceived, and its principle was really applied only when it had been discovered anew in 1866. At this epoch, three inventors disputed with each

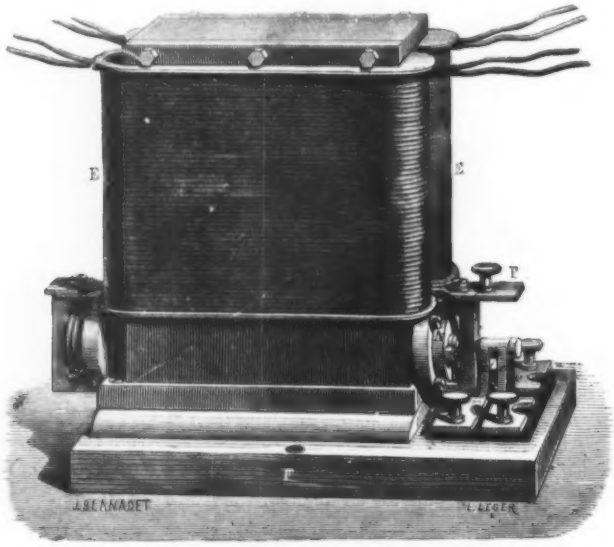


FIG. 9.—WHEATSTONE'S MACHINE.

other the honor of having put forth the principle of superexcitation, and these were Mr S. A. Varley, Dr Werner Siemens, and Sir Charles Wheatstone.

THE MACHINES OF VARLEY, SIEMENS, AND WHEATSTONE.

If we refer to documents that are really official—these are the only ones that can be truly credited—the first in date was indisputably Mr. Varley.

In his provisional specification of December 24, 1866, which he deposited in common with his father, Cornelius Varley, he describes an apparatus consisting of iron horse shoe electro magnets, between the arms of which revolve electro-magnets whose wire is put in connection with that of the first electros through the intermedium of a commutator. The stationary electro-magnets being of soft iron, the inventors say that there should be first made to circulate in their wire an initial electric current, so as to develop in the soft iron a slight magnetization for producing the first current necessary to set the machine in operation.

Between Sir Charles Wheatstone and Dr. Werner Siemens, the priority belongs to the latter. At the Royal Society of London, Mr. William Siemens described his brother's machine the very day on which Wheatstone read a description of his, at the session of Feb. 14, 1867. But the Proceedings* of the society show that the memoir of Mr. William Siemens was deposited on the 4th of February, while that of Sir

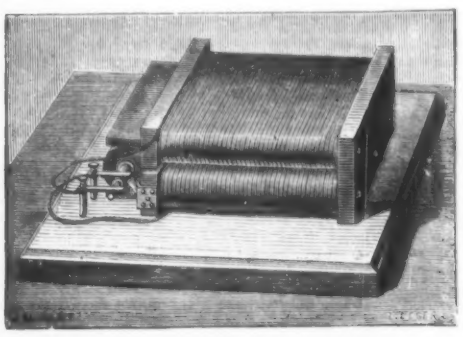


FIG. 10.—SIEMENS' MACHINE.

Charles Wheatstone was deposited only on the day of its being read (the 14th). Besides, Dr. Siemens had himself described his machine in a memoir read before the Berlin Academy on the 17th of January, 1867. An effort has been made to invoke in Wheatstone's favor the invoice of his apparatus which was delivered by the manufacturer, Mr. Stroh, on the 12th of September, 1866; but it seems to us that that is not a sufficient document for the establishment of a priority.

It appears also, from a correspondence published in *Engineering* (numbers for October 26 and December 21, 1877), that Dr. Siemens made his first experiments in December, 1866, before Mr. Varley deposited his caveats and made several official scientists witnesses to it. But we consider this document, which is supported by no publication of the epoch, as having no more authority than the preceding. It appears to us to be more logical, as regards priorities, to consult solely the dates of the published articles, which may be referred to still at the present time.

The Varley machines did not come into practical use, those of Siemens and Wheatstone alone having become the object of applications. The original model of the Wheatstone machine is shown in Fig. 9, and that of Siemens in Fig. 10. As will be seen, they both consist of a Siemens armature revolving between the poles of a flat electro-magnet, and they recall the Wilde machine minus its excitor.

LADD'S MACHINE.

The invention of these machines was soon followed by that of a machine which, at the Exhibition of 1867, attracted a good deal of attention, and this was that of William Ladd, a description of which he addressed to the Royal Society of London, March 14, 1867.* In his memoir, Mr. Ladd says that, having received a Wilde machine in 1864, he tried to improve it. "It was then suggested by my assistant,"* he adds, "that if the armature had two wires instead of one, the current from one being sent into the wire of the inducting magnets, their power would be increased, and there might be collected in the other wire a considerable current utilizable for external work; or else there might be two armatures, one for raising the power of the magnets and the other for producing a current useful for mines or other applications. A want of time prevented me, till recently, from carrying out this idea; but, since reading the interesting memoirs of Mr. C. W. Siemens and Prof. Wheatstone, I have put it in practice in the following manner." Mr. Ladd then goes on to describe the two-armature machine set in motion by the same transmission, revolving between the extreme poles of the flat electro-magnets, and serving, one of them to excite the latter, and the other to produce the effective current. The Ladd machine is represented in Fig. 12. The construction of this apparatus has since been modified in various ways. Thus, Ruhmkorff replaced the two bobbins by a single one divided into two partial bobbins placed at right angles opposite one another (Fig. 11). The current produced by the smaller of these served to excite the inductors, while the other furnished the external current. Mr. Gaiffe also made analogous machines with a single bobbin, but in employing the two wires that were first suggested by Mr Tisley. In their memoirs, Varley, Siemens, and Wheatstone pointed out the necessity of first producing in the iron of the electro-magnets a slight magnetization by means of an auxiliary source. Among them, Siemens alone indicates that, the operation having been performed once, it is not necessary when the machine is set going again to repeat it, since the cores have preserved enough magnetism. None of them, however, seems to have seen that, either as a consequence of the work of the shop or any other cause, the iron of electros is always sufficiently magnetized to allow the machine to prime itself without external action. This fact was put in practice for the first time by Ladd, who points it out especially in his patent of May 2, 1867, when he says that the first Siemens bobbin being set in motion, the *natural magnetism* of its soft iron covering gives rise to an electrical current. The words "natural magnetism" appear to us to indicate very clearly the feeble magnetization that always exists in iron, and we do not think that the first observation of it should be attributed, as has been done, to Wilde* or to Lontin,† because these inventors were the first to use the words *residual* or *remanent magnetism*.

After the excitation of the inductors by the current itself, the most important progress that was effected was the construction of those ring machines which to-day form the base of the industrial applications of electricity. An effort was made last summer to refer their origin to an old apparatus exhibited in the Dutch section, and which was constructed in 1842 by Elias. But this was an error. The Elias apparatus was constructed as a motor and not as a dynamo electric machine.

THE ELIAS MOTOR.

It consists (Fig. 13) of two concentric rings of soft iron, one of them fixed and the other movable. The external fixed ring, supported by the posts, C and C', exhibits six intervals, such as A A', dividing it into six equal parts, and between each of which is wound insulated copper wire, the winding being such that an entering current following the wire, *g*, through one extremity of the horizontal diameter, divides between the two halves of the ring, and makes its exit at the other extremity of the same diameter through the wire, *g'*. Besides, owing to reversals in the direction of the helices, the poles, A A', etc., are alternately north and

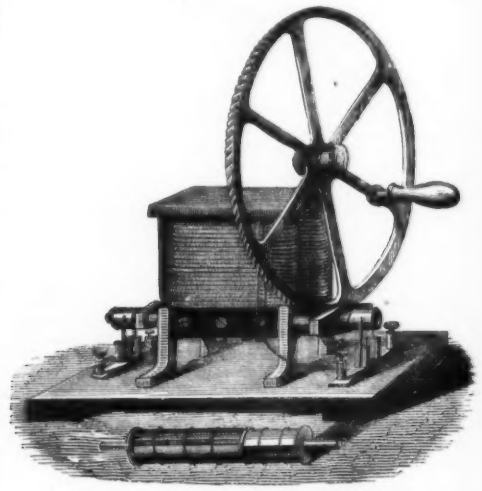


FIG. 11.—RUHMKORFF'S MACHINE.

south. The internal movable ring is constructed in the same manner. The six poles that it presents are always alternately north and south, and the current enters in the direction of the extremities of one diameter through the wires, *f f'*, which end at the commutator, *c*. This latter consists of six equidistant strips of copper, three of which, situated at 120° from one another, communicate with the wire, *f*, and the other three are connected with the wire, *f'*.

To set the motor going, a special pile may be connected with the external ring; the two terminals, B B', from whence the current reaches the commutator through the springs, R R', may be connected with the principal pile; or else only a single pile may be used, and B be connected with *g*, for example, by leading the pile wires to B and *g*. In any case, the alternately north and south poles of the external ring remain invariable. The poles of the movable ring, on the contrary, change direction at every sixth of a revolution, and the commutator is so formed that any one whatever of the poles of this same ring shall be always repelled by one of the fixed poles between which it comes, and be attracted by the other. In the position shown in the figure, for example, if A is north, *a'* is south, and becomes attracted by A, while it is repelled by the south pole at the extremity of the post, C. When *a'* comes opposite A, the change of sign occurs on all the movable poles; *a'* becomes north, and is then repelled by A, and attracted by A'. The same thing occurs with all the movable poles, and all concur to produce a continuous rotation. It should be remarked, besides, that the solenoids that produce the magnetization of the different poles in the two rings are situated very near one another, and there are exerted between the stationary and movable solenoids attractions and repulsions which concur to produce the rotation of the motor.

It will be seen that this apparatus was constructed only

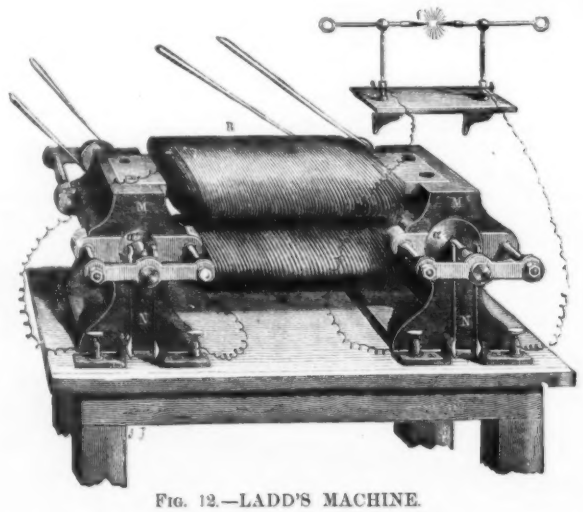


FIG. 12.—LADD'S MACHINE.

* Proceedings of the Royal Society, vol. xv., 1866-1867.

* Proceedings, vol. xv., p. 404.
† Mr. Tisley.

* Patent for his alternating machine. Addition of June 29, 1867.
† Patent of 1869.

with a view to producing an electric motor. It is reversible, it is true, and might become a dynamo-electric machine, but that was a fact that escaped Mr. Elias's attention. In considering it, moreover, as a machine, there will not be found in it, despite its annular form, the arrangements which characterize the present ring machines. It is not the same with the Pacinotti machine, whose construction dates as far back as 1861, and the first description of which was published in 1864 in *Il Nuovo Cimento*.

PACINOTTI'S MACHINE.

Pacinotti describes his apparatus (Fig. 14) in this way:

"I have taken a turned iron ring provided with 16 equal teeth, and this is supported by 4 brass arms or spokes, B B, which connect it with the axis of the machine. Between

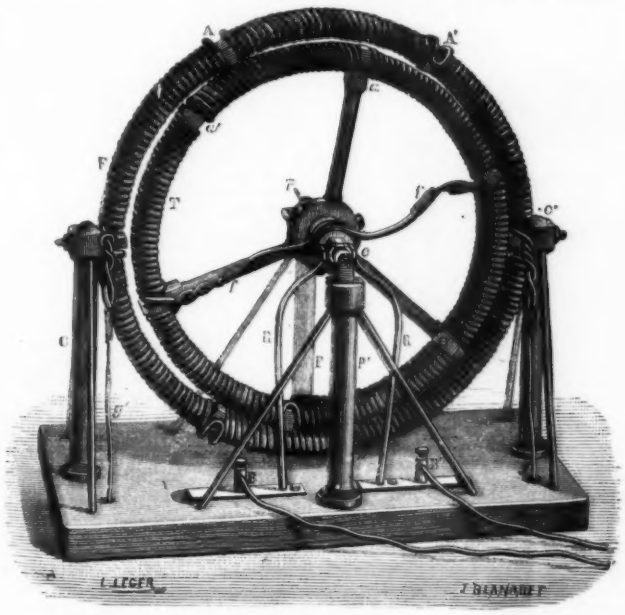


FIG. 13.—ELIAS'S MOTOR.

the teeth small wooden triangular prisms form hollows in which is wound a silk covered copper wire. The object of this arrangement is to obtain a perfect insulation between the iron teeth of the wheel, of the electro-dynamic helices or bobbins thus formed. In all these bobbins the wire is wound in the same direction, and each of them is formed of 9 spirals. Two consecutive bobbins are separated from each other by one of the iron teeth of the wheel and by the little triangular wooden prism. Upon the axis which carries the wheel thus constructed I have grouped all the wires, of which one of the ends forms the end of one bobbin, and the other the beginning of the following bobbin, and have made them pass through holes made for the purpose in a wooden sleeve or collar centered upon the same axis, and from thence have attached them to the commutator, which is also mounted on the axis. This commutator consists of a disk

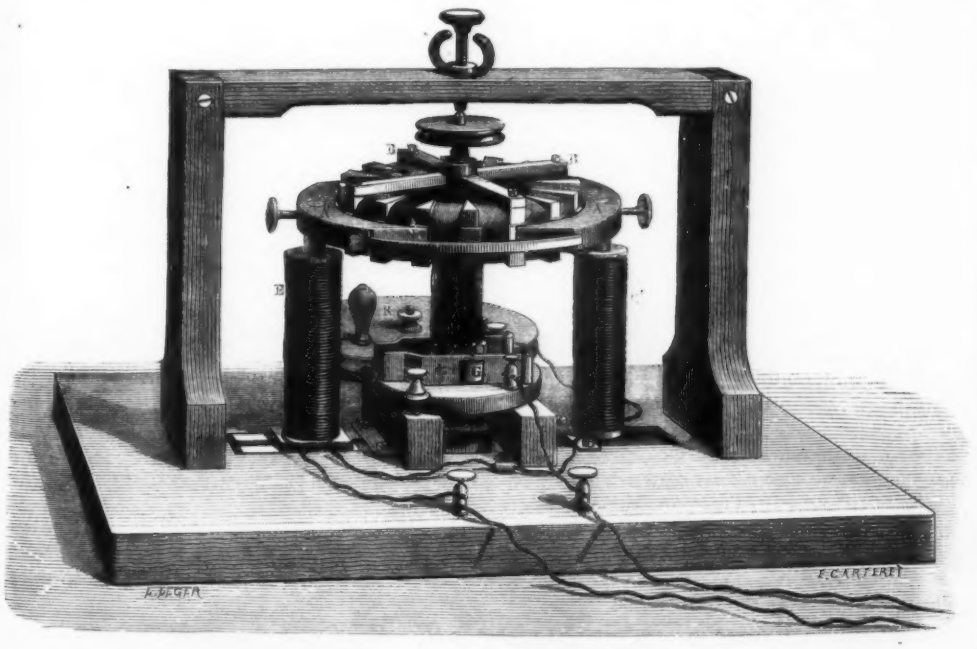


FIG 14.—PACINOTTI'S APPARATUS.

or small cylinder of wood having at the edges of its circumference two rows of mortises into which are set 16 pieces of brass—8 in the upper and 8 in the lower mortises, the first alternating with the second, and all concentric with the wooden cylinder from which they slightly project, and the thickness of which separates one row from another. Each of these pieces of brass is soldered to the two ends of wire which correspond to two consecutive bobbins, so that all the bobbins communicate with each other, each of them being connected with the following by a conductor of which one of the pieces of brass of the commutator forms part. If, then, we put two of these pieces of brass in communication with the poles of a pile by means of two metallic rollers, G, the current, in dividing, will traverse the helix on both sides of the points from whence start the ends of the wires attached to the pieces of brass that communicate with the rollers, and the magnetic poles will appear in the iron of the circle on the diameter perpendicular to A A'. Upon these poles there act the poles of a stationary electro-magnet which brings about the rotation of the transverse electro-magnet around its axis, seeing that in the transverse electro-magnet, when in motion, the poles always reproduce themselves in the fixed positions that correspond to the communications with the pile."

It is impossible to more clearly describe the essential arrangements of the present ring machine regarded as a motor. The very collector that certain persons refused to Pacinotti is perfectly described under the name of *commutator*, and its arrangement in alternate incrustations may, even, in certain cases, be superior to the present arrangement. The details of Fig. 15, which we have put together from the machine exhibited at the Palais de l'Industrie, show, moreover, that there can be no doubt with respect to this.

But Pacinotti not only considered his apparatus as a motor, but also understood that it likewise constituted a source of electricity. "It seems to me," says he, "that what increases the value of this model is the facility that it offers of transforming this electro-magnetic machine into a continuous current magneto-electric machine. If, instead of the electro-magnet, there were a permanent magnet, and the transverse magnet were made to revolve, we should have in effect a magneto-electric machine, which would give a continuous induced current always in the same direction." Pacinotti then gives the same theory in regard to his apparatus as is given at the present day by all treatises on physics: "To cause the development of an induced current by a machine thus constructed, I have placed the opposite poles of two permanent magnets near the magnetic wheel, or, by means of a current, have magnetized the fixed electro-magnet and have made the transverse electro-magnet revolve on its axis. In the first case, as well as in the second, I have obtained an induced current always flowing in the same direction."

Pacinotti, then, is really the inventor of the ring machine, but it would not be allowable, as has been done, to consider him as having applied the principle of superexcitation, because his apparatus contained two electros, and, when it worked as a motor, these were in the same circuit as the ring.

As has just been seen, when he employed his apparatus as a machine he excited the electros by a special source, or replaced them by permanent magnets. He even says, in continuation of the passage quoted: "It is readily understood that this second method is not practical, but that it is easy to put a permanent magnet in the place of the temporary one. The electro-magnetic machine that will result therefrom will then have the advantage of giving increased induced currents all running in the same direction, without necessitating the use of mechanical parts that separate them from the opposite currents, or which make them all concur with each other."

The principle of superexcitation then escaped Pacinotti; but, it will be seen that if we allow 1861 as the date of the construction of his machine, he may be considered as being the first who employed as inductors electro-magnets excited by an external source. If we refer only to the date of publication of his memoir (June, 1864), he is, as regards this, only little later than Wilde. His memoir ends with an interesting remark which seems to be the first notice of the reversibility of electric motors: "This model," says he, "shows, moreover, how the electro-magnetic machine is reciprocal to the magneto electric machine; since, in the first, the electric current that has been introduced into it by the

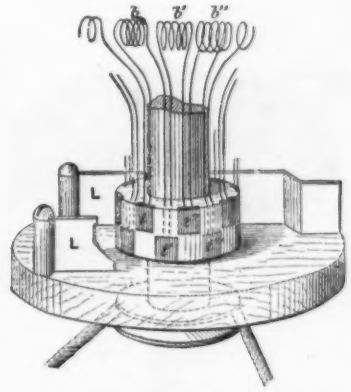


FIG. 15.—PACINOTTI'S COMMUTATOR.

rheophores, on circulating in the bobbins, permits of obtaining the motion of the wheel and its mechanical power; while in the second, there is employed mechanical power to turn the wheel and to obtain, through the effect of the permanent magnet, a current that circulates in the bobbins, flows to the rheophores, and from thence is led into the object upon which it is to act."

As well known, the Pacinotti machine remained forgotten in the physical cabinet of the University of Pisa, and on the 3d of March, 1866, Mr. Worms, of Romilly, took out a patent for a ring machine. This latter, however, differed from that of the learned Italian in that the induced helix, instead of being wound in the same direction, possessed distinct sections communicating in tension with each other and wound in different directions on each half of the ring, in order that the actions of the two poles of the inductor might combine together in the same direction. This machine, moreover, never worked practically, and the ring machine only began to enter into practical use when Gramme, in 1871, invented a machine that absolutely reproduced the principal arrangements of Pacinotti's. Mr. Gramme, more fortunate than the Italian physicist, had the luck to find capital, and, thanks to that powerful help, to see his machine become the starting point of the progress since made; but it is to Pacinotti that belongs the honor of having been the first to discover the so fecund principle of the ring and collector.

SECONDARY BATTERIES.

ON SECONDARY BATTERIES, WITH SPECIAL REFERENCE TO LOCAL ACTION.*

By Dr. J. H. GLADSTONE, F.R.S.

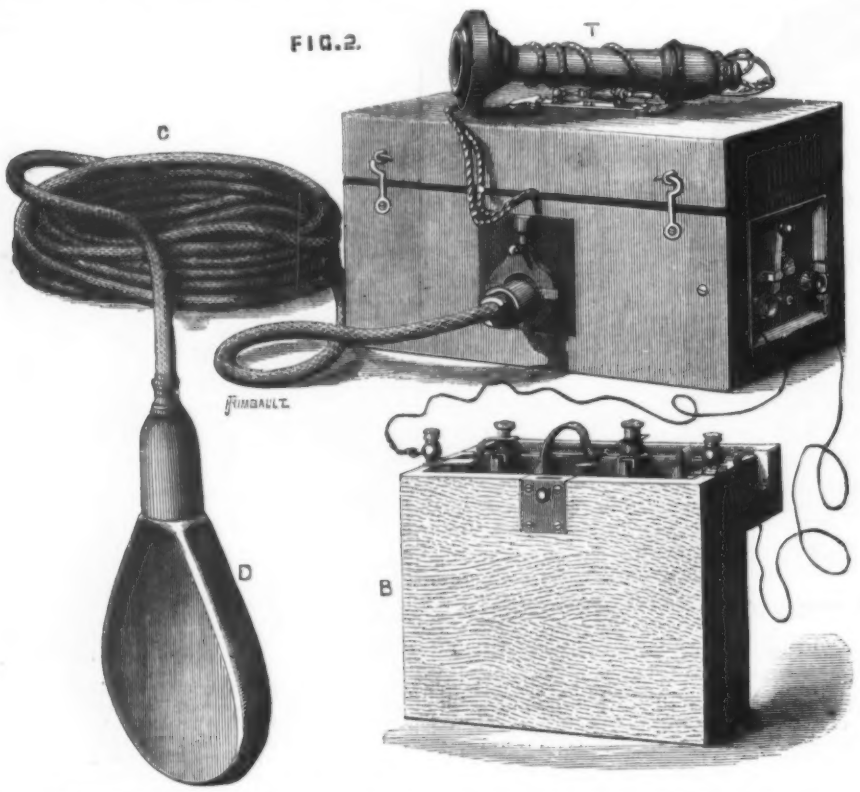
THE elements of which a Planté battery and its curious modifications consist are metallic lead, peroxide of lead, and dilute sulphuric acid. The reaction that takes place is the combination of the positive metal with SO_4, forming $PbSO_4$ (plumbic sulphate), and the reduction of the PbO_2 (peroxide of lead) by means of the hydrogen of the sulphuric acid to PbO (plumbic monoxide), which, in the presence of sulphuric acid, is also converted into sulphate of lead and water. The amount of force which can be obtained from a cell depends upon the amount of peroxide of lead which is capable of being reduced. Now, the negative plate of these secondary batteries is itself an arrangement of lead and lead peroxide, and if immersed in dilute sulphuric acid galvanic action is at once set up. This "local action" is, fortunately, soon diminished by the badly conducting sulphate of lead upon the surfaces of the lead plate and crystals of peroxide. When the two plates are brought into connection the discharge takes place between them, but the local action on the negative plate is not stopped. This is shown by the much larger amount of sulphate of lead produced on the negative than on the positive plate. In experiments quoted by the author this increase amounted in one instance to 53 per cent. The amount of available peroxide of lead that may be thus destroyed on any negative plate is not easily recognized, for the electromotive force is not affected, and the current obtainable in the first instance is not much reduced, though, of course, the same amount of work cannot be got out of the battery. This local action takes place also during the formation of a cell. One of the proofs of this is that much more oxygen is absorbed than could possibly be absorbed in the oxidation of the minium used in a Faure cell; indeed, in one experiment, which was continued for 115 hours, it was found that a small amount of oxygen was being continuously absorbed, though the main action was complete in less than forty hours. This was attributed to the formation of sulphate of lead at the expense of the lead plate and its subsequent oxidation. As this local action impairs the value of these secondary batteries, it becomes an important problem to ascertain what modification of the present arrangements will minimize if not entirely prevent it.

* Abstract of paper read before Section A, Southampton meeting of the British Association.

McEVOY'S ELECTRIC SUBMARINE DETECTER.

THE induction balance invented by Professor D. E. Hughes, F.R.S., has had a number of useful applications, and the latest of these is the electric submarine detecter of Captain McEvoy, whose name is well-known in connection with torpedo work. In his early experiments with the induction balance (see *Engineering*, vol. xxvii., pages 217 and 457, and vol. xxx., page 12), Professor Hughes demonstrated the extraordinary sensitiveness of the apparatus to the presence of small pieces of metal when brought near to one or other pair of coils. The first suggestion of its practical use for detecting metal masses appears, however, to have been made by Mr. J. Munro, C.E., who early in 1880 described an arrangement of the balance adapted to find out metal ores and veins in the ground. This arrangement, which indeed is the only obvious one, is substantially the same as that afterward employed by Professor Graham Bell to locate the bullet in the late President Garfield (see *Engineering*, vol. xxxii., page 145), and by Captain McEvoy in detecting the existence of metal cased torpedoes, sunken iron hulls, lost cables, anchors, or other metal objects on the bottom of the sea.

FIG. 2.



INSTRUMENT FOR DETECTING THE PRESENCE OF METALS UNDER WATER.

The arrangement will be understood from Fig. 1, where P S and P^1 S^1 are the four coils of the balance, arranged in pairs separated from each other and connected by insulated wires. The coils, P and P^1, are joined together through a battery, B, and a key or interrupter, I, thus constituting the "primary" circuit of the balance. The coils, S S^1, are connected through a telephone, T, and constitute the "secondary" circuit of the balance. The interrupter, I, may be either manipulated by hand or automatically, so as to give a continuous action. Whenever the primary circuit is closed by its means, a current trasverses the primary coils, P P^1,

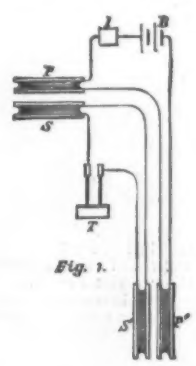


Fig. 1.

and induces a corresponding current in the secondary coils, S S^1. This current is of course audible in the telephone, T; but by reversing one of the secondary coils, say S^1, the current induced by the primary coil, P^1, in the coil, S^1, is made to oppose the current induced by the other primary coil P, in the other secondary coil, S, so that it is possible to cause these two induced currents to annul one another and produce silence in the telephone. In other words, it is possible to effect a practically perfect balance between the two induced currents.

This is done by making the two primary coils and also the two secondary coils alike in all respects, and placing the secondary, S, at the same distance from P that S^1 is from P^1. The final adjustment to produce silence in the telephone can be made by altering the distance between a secondary coil and its primary, say, the distance of S from P, or it can be made by means of a small piece of metal adjusted near one pair of coils, as was originally shown by Professor Hughes. To employ this arrangement for detecting metal masses it is only necessary to obtain a sufficiently good balance in this way, and explore the field where the metal is supposed to may reveal the nuggets in a surface digging, and they may roughly test the richness of a piece of ore brought near them.

The happy idea of applying the balance in this manner has been skillfully worked out by Captain McEvoy, and by dint of patient thought, experiment, and labor he has succeeded in reducing it to a thoroughly practical form. This actual apparatus is illustrated in Fig. 2, above, where A is a portable case containing the adjustable coils, P S, and the interrupter, I; B is a voltaic battery of two cells, which may be replaced by a small magneto-electric machine giving alternating currents; T is the telephone in the secondary circuit; C is an insulated cable conveying the wires connecting up the two pairs of coils; and D is the detecting or exploring case containing the two secondary coils, S^1 P^1. The coils, P S, inside the box, A, are separated by a layer of soft India-rubber, and an ivory screw passes through both coils and the rubber washer between. An ebonite head to the screw is adjusted by hand so as to press the coils together or let them further apart by regulating the pressure between them and the India-rubber. This simple and ingenious device adjusts the balance of induction and reduces the telephone to silence, or as Captain McEvoy prefers it, to all but silence. When the ear has a slight sound to guide it the notable increase of loudness in that sound produced by the approach of the detecting case, D, to a metal body is perhaps more readily observed. Absolute silence is, therefore, not desired by Captain McEvoy in the use of his detecter. The interrupter is another special device which is worthy of remark. It consists of a small iron reed or tongue kept in vibration by a small double-poled electro-magnet, and thereby interrupting the current a certain number of times per second, so as to give out a definite note which is easily recognizable in the telephone and cannot be mistaken. A switch, E, at the box turns the current from the battery on and off the interrupter at a moment's notice. The battery consists of two Leclanche elements in a portable case; but it is probable that chloride of silver cells being much smaller in size will be found more suitable for field operations. A substitute for the battery and interrupter is also provided in the shape of a small magneto electric machine such as are used in the medical applications of electricity. This little instrument gives rapidly alternating currents which, when sent through the primary circuit, do not operate the vibrating interrupter, but produce a slightly musical tone of low pitch which is easily caught and followed by the ear. It forms a useful auxiliary to the battery, and indeed may be employed by some in preference to it. The telephone is the ordinary speaking receiver of Bell, and it, as well as the magneto-machine, are packed inside the box. A sufficiently small battery could also be inclosed therein for transport.

The cable, C, is insulated with Henley's patent core, consisting of India-rubber having its pores filled up with ozokerit or black earth wax forced in under pressure and when in a hot fluid state. It is further protected with an outer braided sheathing, and is fitted to the box, A, by an ingenious socket, which in an instant establishes connection between the corresponding primaries and secondaries, and locks them together. No confusion or imperfection in the contacts is possible through haste or nervousness on the part of those using the apparatus. The detecting case, D, is made of wood soaked with paraffin wax, and its peculiar powder-flask shape, as well as its material, was only arrived at after many trials. It is water-tight, and contains the two exploring coils, S P, Fig. 1. When it is lowered into the water by the cable, C, and moved about, or dragged over the bottom, the instant it comes against a piece of metal such as a torpedo case, a chain, or a submarine cable, it disturbs the balance, and the note, heard in the telephone very faintly until now, becomes unmistakably loud and clear. It is indeed somewhat surprising to find so marked an effect.

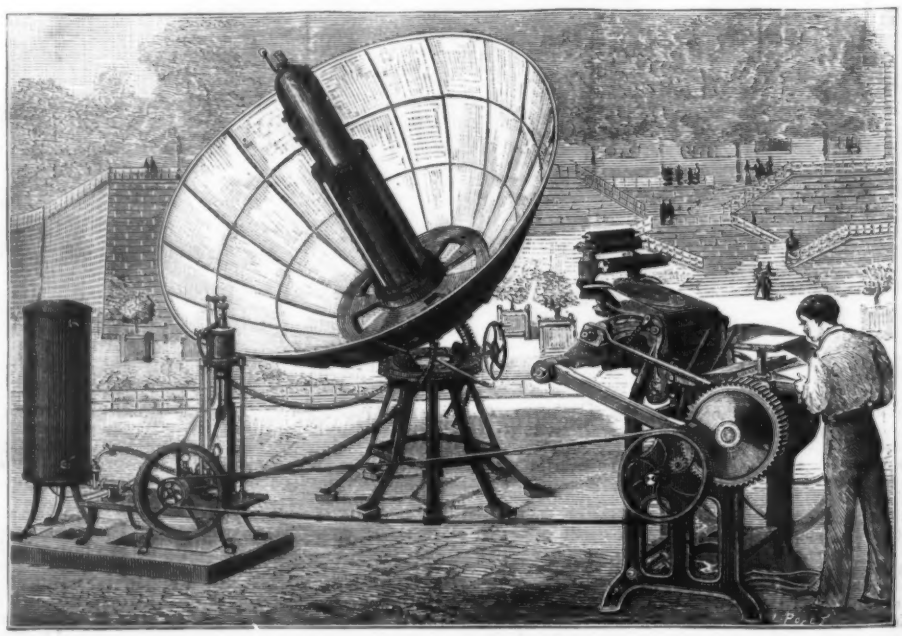
It will be seen from our description that Capt. McEvoy has brought his detecter into an excellent working form, and we are glad to hear that the authorities at Chatham are about to test it on its merits.—*Engineering*.

PRINTING BY SOLAR HEAT.

OUR readers already know of Mr. Mouchot's curious solar generators, and of the remarkable experiments that have been performed by that ingenious physicist for the purpose of turning to account that immense reservoir of heat and motive power, the sun. Mr. Abel Pifre, an engineer, has recently taken up the labors of Mr. Mouchot, and has constructed upon the same principles as those employed by his predecessor as the base of his apparatus, an *insolator*, which gathers the heat of the solar rays in the focus of a mirror, and converts it into mechanical motion.

On the occasion of the *fete* of the "Union Francaise de la Jeunesse," which occurred Sunday, August 6, in the Garden of the Tuileries at Paris, there was witnessed a remarkable experiment with Mr. Pifre's latest improvements in the solar generator.

There was set up on this occasion in the garden, near the large reservoir, at the foot of the Jeu de Paume stairs, an insolator that measured 3·5 meters in diameter at the opening of the reflector. The steam obtained in the boiler carried by the reflector at its focus was utilized by a small vertical motor, of 30 kilogrammeters power, which actuated a Marinoni printing press. Although the sun was not very hot, and its radiation was interfered with by frequent clouds, the press was able to work with regularity between one and five o'clock in the afternoon, and to print on an average five hundred copies per hour of a journal specially composed for the occasion and entitled "Soleil-Journal" (*Sun Journal*). This is not a revolution in the art of printing, but the result is sufficient to allow us to judge of the



PRINTING A JOURNAL BY SOLAR HEAT.

services that *insolators* might render in latitudes submitted to a radiation at once more active and constant.

We could not allow this splendid experiment to pass without preserving a souvenir of it. Our engraving faithfully represents the arrangements adopted. The Pifre insolator is seen in the center of the cut, with its large parabolic mirror; the engine actuated by it is figured at its side; while in the foreground to the right is seen the Marinoni press printing the journal. It seems evident to us that in hot countries the use of *heliodynamics* ought sometimes to prove effective and economical.—*La Nature.*

THE EQUILIBRATING VALUE OF NERVOUS CONTROL.

By J. T. SEARCY, A.M., M.D., Tuscaloosa, Ala.

I BEG leave to offer the following thoughts, in reference to certain functions of the nervous system, that I regard as fundamental facts in modern medicine.

I think the *equilibrating* value of nervous control in the human body, viewed in the light of modern physiology, is a fact that is not sufficiently appreciated, and not brought forward to its relative rank and importance. It is *the* function in the living organization of the greatest value. If we regard the nervous system in the light of its essentiality in preserving or controlling the healthy actions in the body and in the light of its potentiality in transmitting disturbing actions, its *equilibration* comes forward as its most important function.

In illustration of such a position, the following line of argument suggests itself.

In all exhibitions of life, wherever we observe it, the essential phenomenon is, always, *action.*

The amount of action there is constantly and continuously in progress in the human body is immense. In the lowest forms of life structure is simple and action is simple. In the body of man there are many kinds of structure and a great variety of actions, and the necessity for a nervous system uniting and controlling them is apparent. Looking at them all in the aggregate, we can form some idea of the *amount* of *action* there is by observing the amount of machinery in constant action, preparing and furnishing material to support these actions, and also it is shown by the amount of machinery necessary to remove the waste products resulting from such actions. The amount of material consumed and the amount of material thrown off also indicate the amount of constant action.

For convenience, it is easy to divide the actions of the body into *nutritive* and *functional.* The one embracing the processes relating to cell-life; the other the processes relating to the part the cell plays in the economy.

In the human body the complexity of structures and of actions is very great. The complexity of the nervous system exceeds the complexity of other parts of the body. It has functions corresponding to every other function and peculiar functions of its own. The divisions of it into cerebral, spinal, sympathetic, vaso-motor, etc., are by no means well defined. They overlap and intermix by their multiplied connections to such an extent that the nervous system is a whole, and is very rightly called a whole. Its tendrils permeate in every direction, penetrating the tissues, arborating into every cellular structure until probably more perfectly than the vascular system, or connective tissue, if isolated, it would represent fully the figure of the body. The complexity of the cerebral portion of the nervous system is so great that physiologists are lost in the labyrinth. Connecting fibrils cross each other in all directions, uniting parts with each other in such a maze of minute complexity that practically every cell seems connected with every other; parts apparently of different functional action are united closely. What can be said of this portion of this system, more completely isolated, can be said of the rest, to a less complex degree.

The entirety of the body is a fact we are very much given to overlooking. So much is our attention directed to parts and portions that we overlook this as a fact, or neglect the importance of constantly considering it. In our text-books and in our current literature we neglect, I think, the consideration of this fact; that the body is a whole, and especially the fact that it is made whole, in its living actions particularly, through the intimate and multiplied connections of the nervous system. The extreme multiplicity of these connections would warrant such an assertion or belief, if it were not corroborated by other facts.

Noting, then, as a fact, almost self-evident, the immense amount of action there is constantly going on in the body, nutritive and functional, and coupling this fact with the intimate and multiplied connections of the nervous system, we are prepared to appreciate the other very essential and fundamental fact that the nervous system is a medium of transmitting motion or action; of harmonizing, balancing, equilibrating this general action until the body is a grand and a complete community of action. This is a fact, the value of which, the practical everyday value of which, I don't think is sufficiently appreciated. If we bear it constantly in mind, it will help us to explain many phenomena we witness—much of physiology, many of the disturbed or diseased conditions, and much of our therapeutics.

With this sort of an understanding of what is going on, constantly and continuously, in the living body, we can readily describe *health* as a harmonious condition of action everywhere, all equilibrated. In health the structures are normal, according to function, and the actions natural, in accordance with structure and function. The local actions everywhere are not disturbed or disturbing, and the transmitted actions are harmonious, not disturbing, and easily equilibrated or controlled. Our consciousness of such actions is pleasant and agreeable.

Indeed, *physically considered*, we can define *consciousness* as the resultant, the summating in intellectual brain action of all the actions brought to it from all parts. When harmonious, agreeable to intellectual action, our consciousness is pleasant. If there comes disturbing action from any source, our consciousness is disturbed.

Pain can be defined under this sort of an understanding as disturbing action transmitted from the disturbed part to centers of sensation; or more properly, pain is a disturbed action of the centers of sensation. Defectiveness of structure and of functional action, disease in the centers themselves may give rise to pain, without the disturbance being transmitted to them.

Under this sort of an understanding we can define *disease*, anywhere, as a disturbance of structure and of action, whether the disturbance go so far as to make structural changes *visible to the eye or not.*

In accordance with the nerve-connections of a part, and the importance of its functional actions, will disturbing action be transmitted from it to nerve-centers and to the rest of the body. The degree and character of the local disease, *i. e.*, the degree and character of the local disturbance of structure and of action, will characterize the transmitted action.

In inflammation in any part, characterized by the local phenomena, much studied and elaborated nowadays, the action that is transmitted is disturbing in many particulars. Disturbance is shown in cerebral action. Intellectual brain action often shows disturbance; co-ordination and control of muscular action shows disturbance; sensory tracts are disturbed and pain results; nerve-centers that regulate the production and reduction of heat show disturbance and fever results; general cellular action, nutrition, is disturbed. Because of the transmission of the disturbing action, there is disturbance of the various vital actions of the body, respiration and circulation, and the like; general equilibrating control is lost, or, rather, disturbed.

In severe local inflammations the transmitted disturbance is so severe as to jeopardize the general equilibration of the various actions, and if it go far enough it may entirely cessate actions in these principal centers, and the man die—action everywhere stop.

It is impossible to explain all the general conditions of disturbance in disease through the vascular system. You can admit all that can be shown to result from the distribution of morbific material by the circulation, and then not have gone half way in explanation of the phenomena. Bile, carbonic acid, urea, or any other waste products, or the germs of disease, may make disturbing action whenever they reach parts; and because so generally distributed may produce a general disturbance, but the transmission through nervous action of the disturbance thus created has to be allowed, even in these general distribution of disturbing agents, before our explanation of the phenomena will be complete.

The various "sympathetic" and "reflex" actions observed in the body is much easier explained as a transference, by mere connections, not of the natural harmonious action constant in health, but of disturbing action, and such action produces in connected parts disturbance of nutritive or functional action, or both.

It is astonishing how much of our therapeutics can be explained on such principles—the most satisfactory and successful of all our therapeutics.

Take a man laboring from inflammatory action in an important part. It is not necessary to understand all the cellular processes supervening in the inflammatory action. The structure and the actions, nutritive and functional, of the part are disturbed, and disturbance is transmitted; the action in principal nerve-centers is disturbed, and general disturbance is transmitted. His centers of sensation are disturbed and he has pain; his centers of muscular control, of cerebral action, and of the general vegetative processes are disturbed.

He has to lie down, because in that way he gets rid of a great deal of voluntary action that tends to heighten the disturbance. He abates all the muscular and mental action he can. He does all he can to *equilibrate* the general disturbance. "To lie down and keep quiet" is the first general disturbance, especially when the disturbance is of such a character as to injure control of the processes that regulate temperature. "When a man has fever he ought to lie down," is a maxim. Probably, keeping as quiet as he can is all that will be needed for our patient. If that is not sufficient, we can help him often, or sometimes. We can not emphasize too much the advantage of cessating all the action the patient can voluntarily.

How do we usually help medicinally such conditions as these?

In our materia medica we have a long list of agents, with which *in health and in disease* we can, to a greater or less extent, paralyze, stop action in nerve-centers. In health, we can abate, or entirely cessate the action constantly going on in these centers by the administration of such drugs, and we do the same in the time of disease or disturbance. Our medicines act in the same way all the time. The very best medicines we have, the ones we most frequently use, the ones we all carry about with us for immediate and confidential use, are of this character. Take opium, the medicine more frequently used than any other in some one of its forms. In health we can produce in nerve-centers, particularly sensory centers, every stage of abated, cessated, or paralyzed action by the adminstration of different sized doses. We can completely paralyze the centers with it, stop the natural, constant action, and death ensues—or a cessation of all action in the body. In times of disease, or transmission of disturbing action to these centers, how excellent is the effect of paralyzing these centers, so that the disturbance is abated there, or pain stopped, and the transmission of the disturbing action prevented. What would we take for our opium in times of such disturbance! It is well, though, to bear constantly in mind how we are accomplishing the good. We can give it in health when it is not needed, for the pleasurable feeling it produces, and by constant administration damage and disease these important centers; and we can in the time of disturbance overdose, completely stop action, and kill our patient.

I select opium as a very good example of what we may call an *equilibrating* medicine, but the whole list of anodynes and anæsthetics exhibits this property as their principal mode of action, and there are others not usually so classed.

The actions in centers of consciousness and sensation seem peculiarly susceptible to the paralyzing effect of anodynes and anæsthetics because of their extreme sensitiveness, their excessive complexity, their high order of development, if you want to put it.

How often in our therapeutics we resort to the use of medicines that have effect in abating actions in nerve-centers we have only to have our attention directed to the fact to observe. Take, for instance, among the anodynes, the various forms of the opiates, hyoscyamus, cannabis indica, camphor, assafœtida, stramonium, etc. Among the anæsthetics, alcohol, "the grand prototype of all anæsthetics," chloroform, chloral, ether, amyl, nitrous oxide, etc. And then there are a number of medicines like quinine, the salicylates, the bromides, to some extent the iodides, digitalis, aconite, etc., that evidently abate action when administered in sufficient doses in nerve-centers not sensory. Most excellently they come in when indicated.

I have probably illustrated enough to show the value of nerve-equilibration. Recognizing in acute diseases, "inflammatory" disturbances, the nervous system as the medium of transmitting disturbing actions, we readily see how such agents as in health have effect to abate action in principal nerve-centers, will, in disease, be excellent to stop or quiet the disturbance in these centers and the transmission of it through them. We can use them like the policeman does his cudgel, to suppress the leaders and quiet the row, or prevent the transmission of excitement.

When we recognize the controlling, balancing, *equilibrating* value of the nervous system so far as all the various functional actions are concerned, and also so far as the constant, continuous, cellular, nutritive processes are concerned in the body, we have a key to many of the phenomena in health, in disturbance or disease, and to many of our efforts in therapeutics. We ought to keep those facts constantly before us.

The equilibrating value of nervous control is a fundamental principle, around which much of "philosophy of medicine" rotates—*The Medical Record.*

THE CAUSE OF SICK HEADACHE.

IN the *Medical and Surgical Reporter* of July 29, 1882, is an article on the foregoing subject by G. C. Savage, M.D., Jackson, Tenn., in which the author says that sick headache is due to hypermetropia and astigmatism, either alone or combined, and offers as a cure a properly fitted glass. The gist of the paper will be found in the following abstract:

"In the latter part of March, of the present year, the premonitory symptoms of an attack of sick headache warned me of the ordeal through which I must soon pass, unless something could be done to avert it. I did not take the accustomed dose of chloride of sodium, which always gave me as much relief as anything I had ever taken, but had three or four drops of a one per cent. solution of atropia put in my left eye, the one always hurting me throughout an attack, my headache and eyeache being confined to the left side. In half an hour my ciliary muscle was at rest, and I was perfectly free from pain and had no inclination to vomit, whereas, if the atropia had not been put in my eye, by the end of the same half-hour my headache would have been almost unbearable, and great nausea and vomiting would have attended, all to last and to make me most miserable for several hours. I was most happy with the change I had experienced, and felt like crying out, "Eureka!" What gave me relief? The atropia had relieved the tension of the ciliary muscle, putting it at rest, and thus relieving its pain; and, there being no further cause for sympathy on the part of the head and stomach, the pain and nausea ceased. Although I had, apparently, perfect vision before the ciliary muscle was put at rest, I now found my vision equal to $\frac{20}{6}$, *i. e.*, I could see at a distance of twenty feet only letters that, before the atropia was used, when the ciliary muscle had its full power, I could have read at a distance of one hundred feet, and even these large letters seemed double. Now the condition of my ciliary muscle under atropia is just the condition natural and essential to a perfect (emmetropic) eye, when looking at distant objects, and yet the vision of an emmetropic eye would be equal to $\frac{20}{xx}$. Both hypermetropia and astigmatism existed in my eye already at rest, for which I gave the full and proper correction. The glass correcting the defect and enabling me to see without straining, as well as a perfect eye can see, is a combination of a convex spherical of forty-two inches focal distance and a convex cylindrical of sixty inches focal distance, with its axis set at an angle of 95°. I afterward found my right eye both hypermetropic and astigmatic, and gave it the proper correction. Since March I have been doing all my reading and writing with my glasses, with the exception of one week, and for laying them aside for only that short time I paid dearly in suffering from a severe attack of sick headache. The reason for laying them aside was twofold, viz.: 1st, I was using the heavy glasses and still heavier frames of my refracting case, which, on account of their weight, were uncomfortable; and, 2d, I wanted to test their value by not using them. While wearing them I did not feel a single symptom of sick headache. When I put them off I continued reading as when using them, but with inconvenience I had never felt before. I suffered so from the attack of sick headache caused by the disuse of my glasses, that I shall never repeat the folly in the future. I had a pair of spectacles made, and now wear them all the time, and feel that I am safe from attacks, relief from which I had expected nothing but age to give me.

In my own case sick headache had its cause in hypermetropia and astigmatism, and its cure was glasses.

I have had but one other case by which I have been able to still further demonstrate the correctness of my views. That case is a married lady, twenty-six years of age, a sister of mine. She was not so great a sufferer as my mother or myself, but her cure has been as perfect and as reliable as my own. She was hypermetropic in one eye, and both hypermetropic and astigmatic in the other eye. The proper glass for each eye was given her, and now her sick headache is a thing of the past.

Flint, in his work on practice, says that the affection involves a constitutional predisposition, acting with which various exciting causes may bring on an attack. He could not name the predisposing cause. He supposed that some toxical agent must exist in the blood, but says its source and nature are unknown. I claim that the predisposing cause is hypermetropia and astigmatism, either alone or combined, and that chief among the exciting causes is work requiring the convergence of the axes of the eyes with the attending action of the ciliary muscle, such work as reading, writing, sewing, crocheting, etc., which work in an emmetropic eye would produce no bad symptoms.

With Flint I agree that the predisposition, in most persons, ceases at the age of fifty or sixty years. While he gives no reason, to me there is a satisfactory reason, and it is the only one ever offered, so far as I know, it always having been considered an inexplicable fact. My explanation is that it is about the age of fifty or sixty years that, in most persons who are hypermetropic, whether they suffer from sick headache or not, when a latent hypermetropia is converted into a manifest hypermetropia, the ciliary muscle that has had to work so hard during so many years being worn out and ceasing its labors. Long before this has presbyopia (old sight) come on, requiring the person to use spectacles when doing near work, as reading, etc. By this time the hypermetropia is manifest; while during the period through which he suffered, perhaps thirty years or more, the hypermetropia was latent, rendered so by the action of the ciliary muscle.

The periodicity of the attacks may be explained by the eye being able to bear for a time the excessive work it is made to do, when at length its distress is made known by an explosive attack of sick headache, the eye and head aching indescribably, and the stomach, through sympathy, so nauseated as to unload itself of its contents. Even before the attack comes on the stomach performs its functions sluggishly, through sympathy for the overworked eye. Cannot the stomach sympathize with the eye if the eye and head can sympathize with the stomach?

TESTING URINE.

FOR ALBUMEN.

URINE containing albumen becomes cloudy, and yields a flocculent precipitate when heated. If not distinctly acid a very similar appearance may be produced in urine quite free from albumen. In such case it may be due to alkaline earthy phosphates kept in solution by the carbonic acid which they contain, and becoming insoluble when the latter is driven off by heat. This precipitate may be distinguished by the fact that it is soluble in dilute acids, while albumen is not so. A good way to avoid this mistake is to warm the urine until precipitation commences, and then add a few drops of acetic or dilute nitric acid (about two drops to 15 c. c.) and observe if the precipitate redissolves. Or the urine acidified, as just explained, may be saturated with sodic sulphate, and then filtered. It will then indicate the presence of any proportion of albumen which will make itself appear at about 50° C. If the precipitate be quite white it is composed of albumen alone; a reddish tint suggests the presence of blood, and a greenish tint the presence of some of the coloring matter of the bile.

An alkaline urine will not give the characteristic coagulum, even though it contain albumen. The free alkali should be carefully saturated by dilute nitric acid. Acetic acid may give with *mucine* (a substance generally present in alkaline urines) a precipitate liable to be confounded with albumen.

Nitric acid forms a precipitate in albuminous urine, but in applying this test it is necessary to remember that an excess of acid will redissolve the precipitate. The proper proportion to use is 1 part of nitric acid of sp. gr. 1·40 to 10 parts of urine. The urine should be in a conical vessel, and the nitric acid gradually poured in while the vessel is inclined, so that the acid will form a layer at the bottom of the urine. If albumen be present a cloudiness will appear at the point of junction of the two liquids, which will gradually extend throughout the whole. If copaiba, turpentine, petroleum, or styrax be present in the urine, nitric acid will cause a cloudiness, but the odor will suffice to prevent an error from this cause; besides which the precipitate will redissolve if the urine be shaken up with ether or alcohol.

A solution of picric acid, made by dissolving 10 grammes of crystalline picric acid and 20 grammes of pure citric acid in a liter of boiling water, will serve as a test for albumen in urine. It must be added to urine bulk for bulk. Albumen will be precipitated in yellow flakes, which rapidly settle. Peptones in urine will give a similar precipitate, but they may be distinguished by the fact that the peptonic picrate will redissolve in nitric acid, but albumen will not, while albumen is congulated by heat or nitric acid, which is not the case with the peptonic picrate.

Glacial metaphosphoric acid is perhaps the most convenient test for use at the bedside of the patient. It is supplied in small glass tubes. A fragment should be dissolved in a few c. c. of distilled water and added to the suspected urine. It forms a flaky precipitate, or an opalescence, if albumen be present, immediately. This solution should be used the moment it is prepared, as in contact with water the acid rapidly changes to an orthophosphoric acid, which has no effect on albumen.

The color test of Millon is the most usually employed and is the most delicate. This is prepared by dissolving metallic mercury in its own weight of nitric acid (sp. gr. 1·40) and adding at the same time twice its volume of distilled water. After some time a crystalline precipitate is formed. The supernatant fluid is the test. This, added to a normal urine, forms a yellowish-white precipitate, which remains so or becomes slightly rose-tinted on the application of heat. In an albuminous urine the precipitate is of a rose color, which is changed by heat to a red or a brown. But it must be understood that Millon's test affects similarly all proteid substances as well as albumen.

FOR SUGAR.

Urine containing sugar becomes brownish-yellow or black when heated with caustic potash or soda. Normal urine, free from sugar, after exposure of some days or even hours to the air, turns brown under the same treatment. Traces of the dyeing matters of galls or their decomposition products give like reactions, and lastly, the use of rhubarb or senna gives urine the property of darkening in color when treated with alkalies.

Fehling's solution of alkaline cupric tartrate heated to boiling is decomposed on the addition of urine containing sugar, with the separation of dark yellowish-red cuprous oxide. But the reagent will cause a separation of the oxide when boiled alone, if it contains any of the decomposition products of tartaric acid, which are always found when the solution has been long exposed to direct light or has been preserved in corked bottles. In normal, as well as in pathological urines, bodies are found, such as urates and the so-called extractive matters, which also reduce the copper solution. Uric acid and alkaline urates give with Fehling's solution a white precipitate of cupric urate, which is finally reduced to cuprous oxide. If the urine is comparatively rich in urates, this reduction may begin with the first addition to the boiling Fehling's solution, leading to entirely wrong conclusions as to the presence of glucose. To detect sugar in such urine it must be acidified with hydrochloric acid, left for a day, and filtered from the deposit of uric acid. When again made alkaline it can be treated with the copper test, or by the bismuth test, which is not affected by either urates or extractive. Not only is the copper solution reduced by other things than sugar, but the reduction by sugar in urine may be prevented by at least two circumstances. If the urine contains much albumen and little glucose, a compound of copper oxide and albumen is formed, which decomposes slowly. Such a urine must be boiled with a few drops of acetic acid to precipitate the albumen before testing for sugar. The presence of ammoniacal salts hinders the reaction, for the reduction of the copper salt by glucose takes place only in the presence of free fixed alkalies. Putrid urine always contains ammonium carbonate, and must be boiled with a little caustic soda to drive off the last traces of the volatile alkali before adding it to the Fehling's solution.

The presence of glucose in urine is also determined by the aid of Böttger's reagent. This is made by rubbing basic bismuth nitrate with caustic soda solution till it has a pronounced alkaline reaction. When this is boiled with urine containing glucose it turns black, owing to the reduction of the bismuth oxide to suboxide and metallic bismuth. The same coloration is produced by the formation of bismuth sulphide by sulphur compounds in the urine. But in the latter case the blackening takes place in the cold, while glucose affects the color only on boiling.

Another test for the presence of sugar in urine is fermentation by beer yeast. The carbon dioxide produced is led into lime-water, and estimated as calcium carbonate. Often, however, a temporary evolution of carbon dioxide which soon ceases, takes place when the urine contains no sugar. The yeast itself is often saturated with saccharine fluids, and should be carefully washed with distilled water before using it for this test.

The articles from which the above are abstracted appeared in the *Schweiz. Wochensch. für Pharmacie*, where they were quoted from papers by Professor Bruylants in the Annals of the Medico-Chirurgical Society of Liége. The following useful note appeared subsequently in the former journal from Mr. Hahn, of Geneva. Professor Bruylants' explanations of the causes of error in estimations are valuable in doubtful cases, but the following simple method of procedure is quite accurate in all ordinary cases.

To discover sugar in urine he boils in a test tube equal parts of urine and concentrated solution of caustic potash. If this does not produce an increase of color he is satisfied that there is no sugar. If it becomes of a deeper color, turning to a reddish brown, he proceeds to test with Fehling's solution, not too old, diluting with 20 parts of water, and adding only a little urine. If this produces an abundant orange-yellow precipitate, he considers the presence of sugar proved. To titrate this he employs Mitscherlich's polarimeter, having first decolorized the urine by acetate of lead.

To test for albumen he pours a layer of urine on a layer of pure nitric acid, carefully, so as not to mix the liquids. The smallest proportion of albumen produces a characteristic white ring at the point where the two layers meet. He considers this test a very sure one. It is liable to only one cause of error. If the urine be too concentrated it may occasion a somewhat similar white ring, but rather higher up, but this can be checked by diluting the urine in such case with one or two parts of water.—*Chemist and Druggist.*

SNAKE BITE—RAPID CURE BY PHENIC ACID.

DR. SEREINS relates a case of snake bite treated successfully by hypodermic injections of phenic acid. The patient, a charwoman, forty years of age, was bitten by a venomous snake on the left foot, just below the external malleolus. Half an hour afterward she experienced an intense smarting at the point of injury, and a sensation of constriction in the abdomen and epigastric region. Soon she began to throw off quantities of glairy mucus and bile. The vomiting was almost incessant, and each attack was preceded by a painful aura starting from the wound, passing up the limb and radiating toward the stomach. A tourniquet was applied to the limb, and the wound covered with a compress dipped in a solution of ammonia. Dr. Sereins arrived two hours after the woman had been bitten, and found her vomiting and suffering from a sense of impending suffocation. The skin was cold and covered with perspiration, the pulse small, feeble, and beating 110 in the minute. On the external surface of the foot, just below the malleolus, were two little red points, and above them a small blister caused by the ammonia. The lower part of the leg was enormously swollen, the skin marbled, with here and there yellowish spots and points of ecchymosis surrounded by small vesicles. The patient complained bitterly of cold. Four hypodermics of a solution of phenic acid in glycerine (two in fifteen) were given, one in the neighborhood of the bite and three at the upper edge of the œdematous part of the leg. The wound was also bathed with the same solution. In one hour there was a very appreciable reduction of the swelling, the vomiting became less persistent, and ceased entirely in four hours. The next day the constricting ligature was removed from the leg. On the second day the patient had entirely recovered, there was but slight swelling of the leg, and the yellow spots and ecchymosis had disappeared. The case seems remarkable in the rapidity of the cure effected. Few accidents of this kind are ever recovered from (if at all) short of a fortnight. Then the woman was not seen until two hours had elapsed after the wound was inflicted. The nervous centers were profoundly affected, as evidenced by the symptoms. Thus the phenic acid not only destroyed the venom at the point of introduction, but even neutralized its effects in the general system.—*L'Union Médicale.*

GOLD AND SILVER AMALGAMS FOR THE TEETH.

CHLORIDE of silver is prepared by precipitation from the nitrate by adding common salt. A pasty deposit immediately takes place, and when all the silver is thrown down (which is known by the addition of a few drops of hydrochloric acid not rendering the fluid turbid) it should be washed and drained so as to leave a pasty mass. Into this a piece of zinc is immersed. In the course of two or three days (according to the quantity submitted) all the silver will be reduced to the metallic state; you then remove the zinc. To ascertain the weight of silver you have to amalgamate, it is necessary to weigh the piece of zinc before submitting it to the paste, and the loss of weight which the zinc sustains will be equivalent to the weight of metallic silver produced. To this may be added six or eight times its weight of mercury, which must be triturated in a mortar with warm water for several hours, or so long as the mass continues in the least to discolor the water. The operator will discover the pasty adhesiveness which the amalgam will acquire as he proceeds; and for this part of the process it is better to have an excess of mercury, which can be squeezed out, and should leave, at the conclusion of the operation, an amalgam composed of one part of silver and four parts of mercury. This amalgam of silver is to be united with an amalgam of gold. The amalgam of gold may be prepared by putting ribbons of pure gold (similar in thickness to that which goldbeaters commence beating with) into heated or nearly boiling pure mercury, and in the proportion of four mercury to one gold. This may be poured into a mortar containing water, and washed, as the silver amalgam, so long as the lead discoloration appears in the water. This should be freed of its superfluous mercury, and the mass should consist of gold one part, mercury three parts. The amalgams being now perfectly pure, it may be well to keep in separate boxes the little pallets necessary for combination of the compounds, and the proportions are two parts by weight of the gold amalgam to one of the silver. It is found to become a more compact mass by the first crystallization, although, should there be any residue, it may be heated, rubbed up again with a fresh supply for a future operation. The two pallets had better be triturated thoroughly in a mortar before the compound is submitted to the flame of a spirit-lamp, and for the better incorporation it is necessary to submit it to heating and trituration in the usual way three or four times.—*Pharmaceutical Journal* for March, 1850.

ABSCESS OF ANTRUM.

DR. C. E. NELSON, of New York, writes: In bringing the following case before the readers of the *Record*, I wish to draw attention to two points: First, the grave mistake in the original diagnosis; and, second, the ingenious nature of the operation which was subsequently performed.

A gentleman in the prime of life suffered from an extensive swelling of the face with extrusion of the eyeball, caused by an abscess of the antrum. Believing that the trouble was mainly in the eye, he consulted a celebrated New York oculist, who advised immediate removal of the eyeball. Subsequently he consulted Dr. George P. Miles, a New York dental surgeon, who diagnosed abscess of the antrum from a diseased molar tooth. He believed the eye to be uninjured, and gave it as his opinion that, when the pus was evacuated and the swelling reduced, the eye would return to its normal situation.

Instead of extracting the decayed tooth and puncturing the antrum with a trochar, as is usually recommended in such cases Dr. Miles drilled through the tooth and socket into the antrum, and through this small opening perfectly evacuated the abscess cavity; the swelling rapidly subsided, and the eyeball returned to its normal position. The decayed tooth was subsequently treated, and the patient eventually made an excellent recovery without losing either eye or tooth. The importance of accurate diagnosis in such a case is self-evident. —*Can. Med. Record, June.*

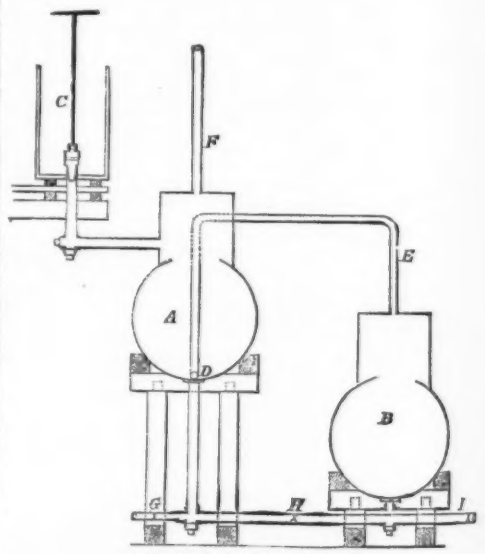
ALVEOLAR ABSCESS.—PEROXIDE OF HYDROGEN.

DR. WALTER COFFIN says: The perfect application of any medicament to all parts of a large and inaccessible abscess always presented considerably mechanical difficulties, and it has occurred to me that, for the hydraulic or pneumatic pressures which are usually applied, there might be substituted some rapid chemical evolution within the cavity. I carried out this idea of injecting into a large abscess in my own mouth which had resisted all the ordinary applications of carbolic acid, creosote, and every other known remedy, as strong a solution as I could obtain of peroxide of hydrogen. This, if cold and rapidly injected, almost immediately afforded a rapid evolution of oxygen upon the whole surface of the abscess, and a more satisfactory antiseptic than nascent oxygen could scarcely be conceived. The liquid when injected was perfectly clear, but the operation was immediately followed by an enlargement of the cavity and the exudation of a white milky froth. The result was extremely satisfactory, a single injection of the peroxide effecting a complete cure.—*Amer. Jour. Dental Sc.*

[JOURNAL OF GAS LIGHTING.]

THE PRODUCTION OF AMMONIA WATER.

As in the apparatus used by us we are able to produce water of a specific gravity below 0·900, and containing 27 per cent. of ammonia, at a single distillation, and from liquor of 5 oz. strength (distillation test), a short description of our process may be of interest.



AMMONIA APPARATUS.

Our plant consists of two stills, one rectifier, and a system of three-quarter inch condensing pipes, cooled by the evaporation of water sprinkled over them. The ammonia gas is absorbed into water contained in sheet-iron cylinders holding about 150 gallons. The arrangement of the stills is shown in the preceding sketch. A and B are the stills, so connected that A may be emptied into B by opening the cock, H. C is the lime-box; I is the cock through which B may be emptied; G is a cock for admitting water to loosen the lime, which occasionally stops the connecting-pipe between A and B; F is the pipe leading to the condensers and absorbers. The contents of B are heated by means of a steam coil. The operation is as follows: The liquor in B having been exhausted of ammonia by means of heat from the steam coil, the cock, I, is opened, and the still emptied. Next the cock, H, is opened, and the still, A, emptied into B. H being closed, enough lime for the absorption of the carbonic acid and sulphureted hydrogen in the new charge is mixed with gas liquor in C, and run into A. This still is now charged with liquor, and steam turned on the coil in B; the vapors from the boiling liquor passing by means of the pipe, E, to the perforated pipe, D, extending from end to end of the upper still. After bubbling through the fresh charge in A, these vapors, now rich in ammonia, pass off through F to the rectifier, a large cylinder in which, the motion of the vapors being diminished, mechanically suspended particles of water settle out; thence to the condensers. The condensed water, saturated with ammonia, drains back into the upper still. By this method of working, gas liquor of any strength may be brought to yield vapors so rich in ammonia that the water condensing from them will not carry back with it to the still all the gas, but leave some to travel on to the absorbers. Starting with both stills containing crude 5 oz. liquor and

lime, it requires several changes to so enrich the vapors that any considerable amount of ammonia will reach the absorbers; but, when this point is once attained, each charge sends all its gas to enrich the water.

Working in the way I have described, we are able to produce ammonia water of 29° Baumé scale, when the temperature of the air is 90°, and our cooling water more than 80° C.

WALTON CLARK.

New Orleans, July, 1882.

JUBÆA SPECTABILIS.

PROFESSOR HENRIQUEZ, the Director of the University Garden of Coimbra, has been good enough to send us a photograph of this noble palm, as growing in the open air in the gardens of His Majesty the King of Portugal, at Lisbon

JUBÆA SPECTABILIS IN THE KING OF PORTUGAL'S GARDEN.

(see Figure). The girth of the trunk near the base was 4 m. 25 cent., or about 13½ feet. At one meter from the ground it measured 3·50 m. in circumference. The height from the ground to the first leaf is given at 2·57 m., the total height in meters being 7·74 (more than 23 feet). These measurements were taken some few years since. its present height being 8·55 meters (27 feet). In the same garden may be seen other palms, a fine specimen of Strelitzia angusta, good specimens of Cycas revoluta, one with a forked stem. The mango —Mangifera indica— has produced flowers in the open air. The King is a well-known connoisseur in plants, taking much interest in his collections. "In the Botanic Garden at Coimbra," writes Professor Henriquez, "Phœnix silvestris, P. reclinata, Livistona inermis, Arenga sapida, Seaforthia elegans, Sabal adansoni, S. glaucescens, Cocos romanzovii, and other palms, flourish in the open air, as well as bamboos 12 meters in height, and Musa ensete."—*The Gardeners' Chronicle.*

OPIUM PRODUCTION IN CHINA.

IN a volume of commercial reports by Her Majesty's Consuls in China, just issued, there is an unusual amount of space devoted to the subject of opium. As might be expected, the commercial and political aspects of the question occupy the most prominent positions in these reports, but intermixed there is some information upon the cultivation and consumption in China of native-grown opium which appears to be worth culling for these columns. Especially is this the case with the report of Mr. Consul Spence, who has recently spent four months in the province of Szechuan.

It appears that, notwithstanding the pretended opposition of the Chinese Government, the cultivation of the poppy is now carried on in every district of the province of Szechuan, in the south west of China, except those on the west frontier, but most extensively in the districts of Chungking Fu and Kweichow Fu Opium is a winter crop, and some of the districts are said to appear at that time of the year like vast poppy fields. For this reason the crop is becoming a great favorite with the farmers, as it does not interfere with rice, the staple food of the people, for when it is planted in paddy lands, as is often the case, it is gathered in time to allow rice or some other crop to follow. Moreover, the conditions under which the tenant farmers hold their land have also hitherto had a similar tendency, as the rent usually consists of a proportion of the summer crop. Landowners are now, however, becoming alive to the importance of the winter crop of opium, and are commencing to stipulate for the payment of a proportion of it also. There seems to be some difference of opinion as to the remunerativeness of opium cultivation. Baron Richthofen, writing ten years ago, estimated the yield of opium at 200 ounces per acre; but Mr. Baber, a subsequent observer, has estimated it at double that quantity. Mr. Consul Spence's figures approximate more closely to the latter, he giving an average of 350 ounces per acre. Probably the difference is attributed to the fact that the cultivation is now more carefully carried on and the land well manured. Every part of the poppy plant has a market value: the capsules are sold for use in medicine; oil is expressed from the seeds; the oil cake and leaves are used for manure; and the stalks are burnt for potash. Taking all these sources of revenue into account, opium, as compared with wheat, is estimated to yield a crop of double the value.

A few years since in Szechuan the poppy was grown only on hill slopes of an inferior soil; but now it is cultivated everywhere, and the country people are agreed that it is most profitably cultivated on good ground with liberal manuring. This agrees with experience in India, where it is found to be best grown on rich soil near villages where manure can be easily obtained. According to Mr. Consul Spence the method of cultivation now followed in Szechuan is extremely simple. As soon as the summer crop is reaped the land is plowed and cleaned, roots and weeds are piled in heaps and burned and the ashes strewed over the ground, and the land is liberally treated to dressings of night soil. The seeds are sown in December in drills 1½ feet apart, the white poppy being by far the most commonly cultivated in the low grounds, though the red and purple varieties are also grown. In the following month, when the plants are a few inches high, the rows are thinned and earthed up so as to leave a passage between each, after which the plants are left to themselves, with the exception that the earth is occasionally stirred and is kept clear of weeds. In March or April, according to the situation, the poppy blooms, and as the capsules form and fill fresh dressings of liquid manure are made. In April and May the capsules are slit and the juice extracted. The total amount of opium produced annually in South-west China, chiefly in the provinces of

Szechuan and Yunnan, is estimated at upward of thirteen thousand tons, or more than twice the whole Indian import into China.

The principal part of the opium exported from the province of Szechuan is carried along mountain paths, on the backs of coolies, to Shashih, and passes from thence into the regular trade channels over the east and south of China; the more convenient mode of transit along the Yang-tsze River is avoided because of the heavy dues. The opium thus becomes available to the poorer classes who cannot afford the high-priced Indian drug. But its cheapness is alleged to be in some degree due to adulteration with oil, glue, and other substances, although when pure it is said to be almost as good as Indian opium.

Some statements by Mr. Consul Spence as to the extent to which opium smoking is practiced in Western China, and the consequent effects, are sufficiently astonishing. He says that the impression one gets in a Szechuan city or village is that every one smokes; there it is no question of fractions of 1 per cent., but of 30, 40, or even 60 per cent. of the whole male adult population, besides a large number of women. In the city of Chungking, for instance, where there is a population of 130,000, there are 1,230 opium shops, with a daily consumption of 12,000 ounces of opium. In country hamlets and villages, also, almost every second house in the main streets is an opium shop. In some rural districts the people smear the lips of their idols with the drug, and at funerals burn paper imitations of pipes of opium, so that the dead may enjoy in the next world the solace they loved in this. Sometimes as many as five "drawings" are smoked from the same opium. The leavings of the rich smoker are mixed with the opium sold to the poor; the refuse of the poor is resmoked by some more destitute; and even the unsmokable dregs are drunk in tea by laborers, sailors, and others who have not time to knock off work for a smoke. But notwithstanding this abandonment to opium-smoking, and the fact that extreme excess in this as in other cases brings its punishment, the Szechuan people are described as being stout and able-bodied, and their general health and well-being remarkable, as well as their capacity for work and endurance of hardship. Mr. Spence sums up by saying that were Indian opium the fatal scourge it is sometimes asserted to be, there ought to be found in the west of China, where ten times more opium is smoked than elsewhere, a debased, debilitated, and impoverished population. But he holds that the reverse is the case, and that the people are both in body and estate among the most prosperous in China, and he considers that unless it can be proved that Indian opium contains some noxious principle which does not exist in the Szechuan drug the hypothesis as to the poisonous effects of opium-smoking is open to grave doubt. But it is worthy of remark that Indian opium is almost unknown throughout this vast district.—*Pharmaceutical Journal.*

THE DEVELOPMENT OF THE TREE TOAD.*

By MARY H. HINCKLEY.

A RECORD of several seasons gives the appearance of *Hyla versicolor* in the spring, in Milton, Massachusetts, from about the 1st to the 10th of May. Tadpoles of this species I have found most abundant in the water of small, still, shadowy ponds near large trees. The eggs are attached singly and in small groups for a distance of one or two yards along the grasses which grow up and rest on the water. Unless the grass is parted they are not readily seen. The gelatinous substance surrounding the eggs is exceedingly thin. When first laid they are of a drab color on the upper surface, which becomes lighter after a few hours in the water. The under surface is white; the extent of this color varies; in some cases only a spot of drab is seen on an otherwise white egg. The period of egg-laying, according to my observations, extends from the first week in May to July. The development of the egg is rapid, being accomplished within forty-eight hours. When first hatched the tadpole is about a quarter of an inch long, of a pale yellow color, dotted with olive on the head and sides of the body. During the first week the external gills are developed and resorbed. At the same time the olive color gradually increases and deepens till it extends over the upper surface of the tadpole. A fine dotting of gold color also appears on both upper and under surfaces. In the water, however, they look black. The holders, at first so prominent, disappear within ten days. The head and body are short. The tail is broad and thick. The eyes are prominent, set widely apart, and of a brilliant flame color; the iris in some specimens is quartered by dark lines. The lips are broad. The nostril openings and two perpendicular lines on the muzzle, also a line from before the eyes down each side to the tail, are gold colored. Transverse bars of the same tint on the upper edge of the tail are sometimes seen.

The tadpoles are shy and quick in movement as young fishes, moving through the water with the least perceptible motion of the tail. They do not collect together, but where there is room enough, each tadpole goes its own way independently. They are hardy, and probably owing in some degree to their quick movements, are more exempt from mutilation by water enemies than other species, rarely losing eyes or tail.

When about three weeks old the hind legs are in sight as small white buds in front of the base of the tail near the lower edge on each side. An iridescence of great brilliancy is seen on the white surface of the abdomen and sides of the body. The head and upper portion of the body show a bluish, metallic sheen, and the tail, which is more or less flecked with brown or black, becomes in some specimens a bright red color. It would be difficult to exaggerate the beauty of coloring of these tadpoles; it exceeds in brilliancy and variety any species found in this locality.

As the legs become more fully developed, the coloring of the head and body tends from dark olive to a light grayish-green. In the seventh week the body begins to lose its roundness, and the arms are seen to be moved under the skin, as if the tadpole were impatient to get them free. The head then appears disproportionately large. At this stage the tadpoles vary from gray to pea-green in color. They are found in the shallow water near the shore, where many fall prey to various aquatic birds. During the eighth week they appear to take little food; the arms are thrown out, the tail is gradually resorbed, the mouth developed, and the frogs leave the water. While a few specimens retain the color of gray up to this time, nearly all will be found of various shades of tender green on the upper surfaces, bordered with different tints of gray or salmon color. The abdomen is white. Green asserts itself much earlier in some specimens than others; but I have never seen a tadpole of this species develop into the frog that did not sooner or later become green. The markings on the back also vary in time of appearance; but the coloring of black on the head, body, and limbs, the smooth shiny patch below the eyes, the granulated appearance of the skin, and the yellow coloring in the folds of the legs, usually appear in the order of their mention, and after the frogs have left the water.

Last season a small pond in an open pasture, about fifteen rods from a wood, furnished a good opportunity for observing their movements on leaving the water. From the 19th to the 24th of July, numbers of the young frogs, with tails in different stages of resorption, were found on the ground, weeds, and grasses about the pond, which by this time had become reduced by evaporation to a shallow pool. They represented a variety of shades of green; a few were gray, and occasionally one was scarcely to be separated in color from the mud on which it rested. I observed those on the ground frequently capture the small spiders which were numerous there. As soon as they left the water their object, evidently, was to reach the wood. Apparently aware of their danger in this exposed journey, they drew attention to themselves, when approached, by continually springing out of harm's way; but after the shrubbery was reached they rarely made any attempt to escape when discovered, trusting wholly, like the mature frogs, to their disguise of coloring for safety. I found several of them on a small apple tree which was in the line of their journey. They were on the new growth which was overrun with aphides, and the frogs had assumed a deep emerald-green, so like the leaf that it was difficult at first glance to distinguish them from it. After they reached the wood I could trace them no farther. I think it probable that some observers have mistaken *H. versicolor* at this age for the adults of another species of Hyla.

My knowledge of the frogs from this stage till they reach maturity is confined chiefly to those reared in a fernery. For the first three months they retained the green color, as a rule, with occasional changes to tints of brown and gray,

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matching the earth or branches to which they clung. After that time shades of gray became the rule and green the exception. The black markings on the head, body, and limbs did not change excepting to vary in distinctness. Their food, which they never took unless alive, was aphides at first, but soon flies formed their chief diet. During the day they commonly remained motionless, hidden behind the bark of the branches, with feet and hands, which are evidently extremely sensitive, compactly folded under the body, so that only their outer edges came in contact with the surface on which they were seated. Occasionally they would pat the disks against the sides of the body as if to moisten them. Their activity was reserved for the night, although rain accompanied by a south wind caused them to move about uneasily. About the 1st of October they left the branches and ferns and nestled away in the damp earth and moss, where they remained through the winter, unless exposed to a temperature above 60°. They took no food from the first week in October till the 14th of the following May, when I gave them their liberty. They were then placed on an oak tree, where, after climbing till a suitable crevice or hiding place was found, they backed themselves into it and became to all appearance like a part of the bark of the tree.—*Amer. Naturalist.*

* Abstract of a paper published in the Proceedings of the Boston Society of Natural History, vol. xxi., Nov. 17, 1880.

OSSEOUS TISSUE FORMED FROM TRANSPLANTED BONE-MARROW.

PROF. BRUNS, of Tubingen, reports (*Arch. for Clin. Chir.* the results of some experiments he has lately made on animals, with the object of determining whether portions of transplanted bone-marrow can give rise to the formation of deposits of true osseous structure. The professor states that the animals best suited for experiments of this kind are young dogs. A portion of the shaft of the femur or tibia is resected, and the marrow contained in this resected fragment, removed in an unbroken cylinder. Portions of this cylinder are then inserted into fresh wounds on the breast or back of the same animal, either into the subcutaneous fat or in a superficial part of the muscular layer. The wounds are then carefully closed by means of sutures.

The following changes, it is stated, take place in each instance of successful transplantation. A diffuse swelling is at once formed, which speedily begins to diminish, and is replaced about the fourteenth day by a movable nodule, in which bony tissue already exists in scattered foci. By the twenty fourth day, foci have usually amalgamated into a single piece of bone. Microscopical examination proves that the nodule, in its early stages, is composed of osseoid tissue, cartilage, and newly formed osseous tissue, and that the fully developed hard mass consists of true bone

These experiments, Prof. Bruns asserts, prove that bone-marrow, completely separated from its connection with bone, transplanted under the skin of the same animal at a remote part of the body, may give rise to the formation of bone and cartilage.—*So. Pract., June.*

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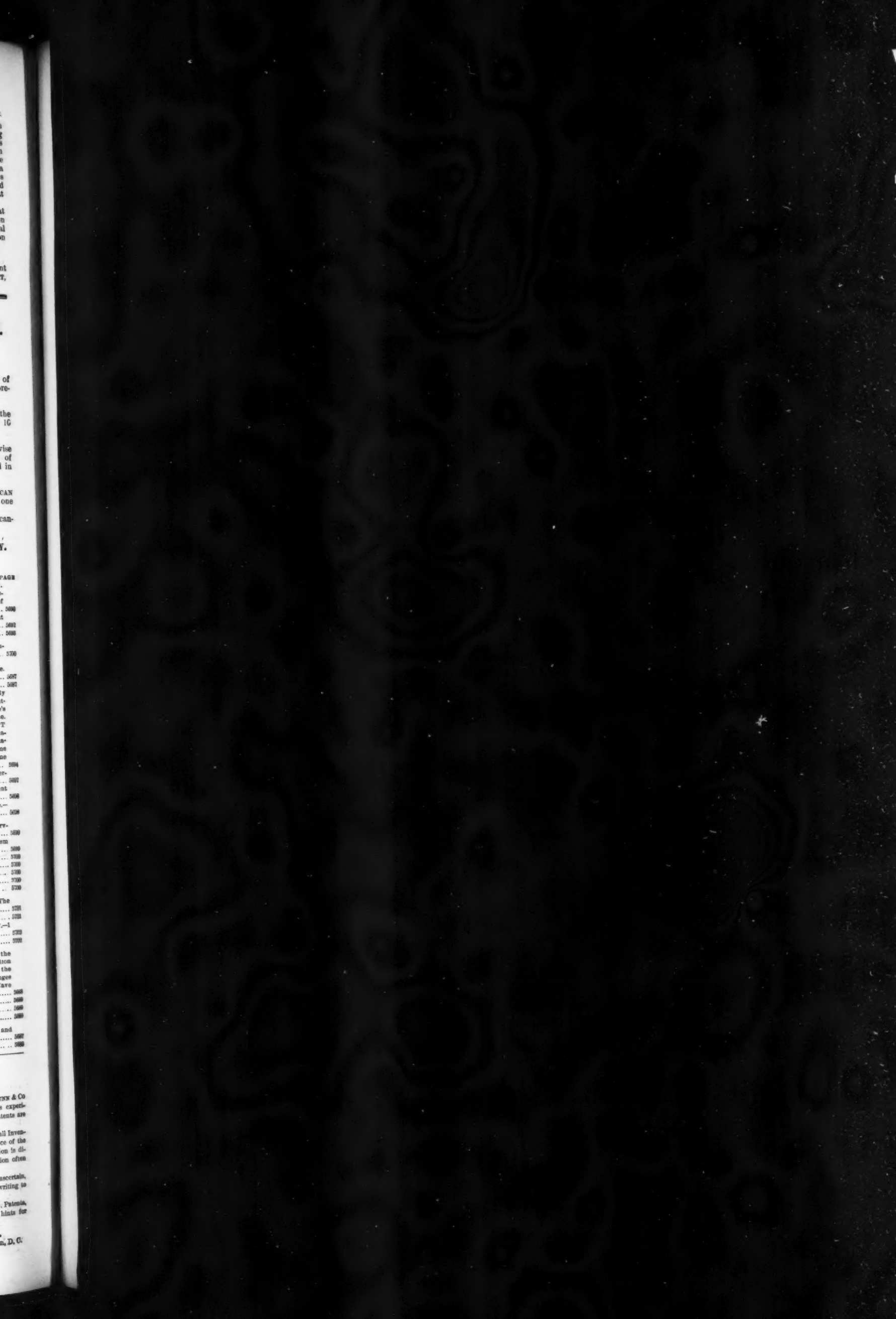
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